DR. WILLIAM WHEWELL.

THE

# POPULAR SCIENCE MONTHLY.

*CONDUCTED BY E. L. YOUMANS.*

VOL. VII.

MAY, 1875, TO OCTOBER, 1875

NEW YORK:
D. APPLETON AND COMPANY,
549 & 551 BROADWAY.
1875.

THE

POPULAR SCIENCE MONTHLY.

MAY, 1875.

# SEA-ANEMONES.

By Rev. S. LOCKWOOD, Ph.D.

EVEN in minds the most illiterate you will find a sort of philosophy, if you but look for it. Among the dwellers by the shore is a class known as Watermen. These men, with great irregularities of toil and idleness, obtain the support of their families wholly from the bounteous, though sometimes precarious, harvest of the sea. Often one finds among them men of the roughest mould, yet with generous natural gifts, but without either education or culture. Of natural phenomena, in a practical way, they are shrewd observers. They know a good deal, too, about many queer forms and strange habits belonging to the denizens of the deep. In their way, they are positive men, and real empiricists too—for, from their limited lookout, and their small stock of facts, they will generalize as broadly as do some scientists upon a few experiments. An old waterman, who could not read a word, said to us: "Sir, Nature works the same in every place. There's nothing on the land what isn't in the sea; and I've even seen ships in the sky!" Here, then, although not a little empirical, in our fisherman's philosophy was a splendid generalization. And how broad it was! It covered every province possible for human experience, in his conception—the earth, the sea, and the air.

And empiricism begotten of a spirit in no wise nobler, abounded in the elder science. Thence have come down to us those heated controversies on the supposed vegetable nature of the polyps that build the corals, and other similar structures in the great deep. And there was that temporary calm which set in upon that stunning clincher of that empiricist, who declared that the coral polyps were, and must be, plants, for—"I have *seen* the flowers!" And Sir Wiseman was true. And so was the fisherman true, when he said, "he had seen ships in the sky." Each in his own way had seen a mirage.

But that clincher would not stay clinched. As concerned their external forms, all admitted them to be sea-flowers. Still, these flow-

ers of the ocean would insist on behaving themselves in divers ways, looking strangely in the direction of sentient things, albeit their plant-like aspect looked contrariwise. Could Nature, just here, Janus-like, look two ways at once? Might it not be that these mysterious things were the habitants of a certain border-land of life? Another empiricism—a generalization as splendid as that of the fisherman. So in complacent wisdom they called them zoophytes, namely—

Animal-Plants.—Time, and a love of truth, will set a good deal right that seems inveterately wrong. Even this brilliant compromise must yield to the verdict that accrues from the patient study of facts generously collected and carefully collated. So this Janus myth, the zoophyte, which had become a cant word in science, turns out to be of no value as representing a fact in Nature. Though flower-forms they were, yet they were really animate things, and capable of acts indicative of will.

Our object now is to say something of one of these flower-like types of marine life, namely, the Sea-Anemone. It is significant, as showing the suggestiveness of these creatures, that, however diverse the nomenclature of science may be in regard to them, it is often almost poetical, and the words used are always expressive, and even possess pictorial significance. De Blainville named them *Zoantharia*, from which comes Animal Flower. Dr. Johnson's term took a wider latitude, and, although quite formidable-looking, and not in the best taste, was very significant. He gave the name, *Zoophyte helianthoidea*, which is to say, the Sunflower-like animal-plant. In these terms the animal nature and the flower-like form are intended. The creature is really a polyp, a soft, almost pulpy, sac-like structure, with a fringe of tentacles, like a halo of rays, around the upper end; in the centre of the circular fringe, the mouth, or oral aperture, being situated. Hence it is often spoken of as an actinia, which really means possessing rays. The word is now worked into another word, *Actinozoa*, meaning rayed-animals, that is to say, animals with rays around an oral disk. But the term is used to designate a class; hence it includes all the polyps, those that construct coral, and the others. This class is again divided into several orders, one of which is named *Zoantharia*, or, as it is sometimes called, the Helianthoid polyps. It is in this order that the actinia proper is found; and, therefore, it is there that we must find our sea-anemone.

Having found for this pretty object, in a system of science, "a local habitation and a name," let us see if we can make out the structure of a sea-anemone, or, as it is often called, an Actinia.

Taken in the hand, the sea-anemone imparts a slippery feeling, and it seems to have the consistency of leather. To get at its precise form, look at the cut given of *Actinia rosea*, a British species. Now, please follow closely our description a little while. As the actinia erects itself, attached to a rock or stone, it looks like one of the purses

formerly fashionable, if one such could be made to stand of itself erect, and have the frill around the upper end to project in a circle. But we must be more particular than this. The upright part, that which is called by naturalists the column, is hollow, like a sack. Its base is really a sucking-surface, enabling it to adhere to any hard object. By this sucking base it can glide, or travel along, much like a snail.

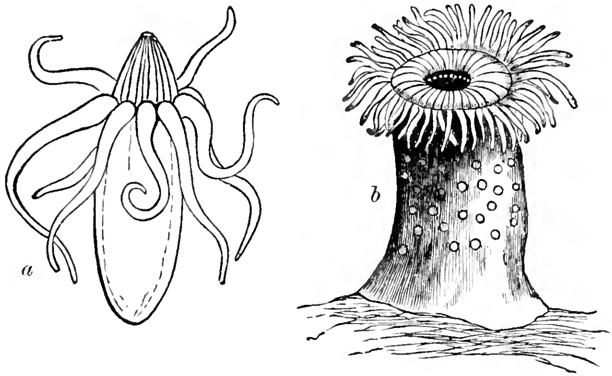


FIG. 1.—*a*, ARACHNACTIS ALBIDA; *b*, ACTINIA ROSEA.

And as it thus moves, it can keep its flower spread out, and its many tentácles in constant play—in fact, fishing on the way. Their movement is, however, very slow. Indeed, a "snail-pace" would be alarmingly fast for an actinia. We have watched them attentively, and have found that an inch in an hour was a very satisfactory performance. At the top is an opening, called the oral cavity, which, in the *rosea*, is surrounded just inside with a beading of little dots. This opening may be called the mouth, because the food is passed at this aperture into the stomach, which is a cylindrical sac, suspended below, and reaching about half-way down the great cavity of the column. Around the oral cavity, and external to it, is a plain surface, which is technically known as the "disk." Around the disk, on its outer edge, is the fringe of tentacles. Each one of these is a little hollow cylinder, opening into the great cavity of the column immediately under the edge of the disk. In fact, these tentacles, or feelers, connect with the interior of the stem of the Anemone, just as the fingers of a glove do with the interior of the same. We should also mention that, at the bottom of the sac, which is here called the stomach, is an opening into the general cavity. Now, around this suspended stomach, that is, between its outer wall and the inner wall of the column, is a system of compartments in series. These vary as to number in the different species. By looking at the cut showing a cross-section of an actinia's stem, we observe that six of these compartments are complete, and reach from the stomach to the walls of

the column. These six compartments are made by as many radiating vertical plains, whose edges on the one side are in contact with the inner walls of the column, and the edges on the other side touch upon the outer walls of the stomach. Between these compartments are others of less capacity. It is noticeable that these are, in like manner, formed of vertical plains, of different widths; and, further, that they are only attached on one edge, and that to the inner walls of the

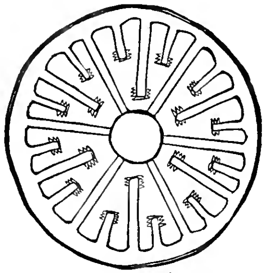


FIG. 2.—CROSS-SECTION OF AN ACTINIA-STEM.

great column, that is to say, they do not connect with the stomach. To understand the relation of these different walls of the compartments to the entire structure, a glance at the diagram will suffice, when it is borne in mind that the transverse section, thus represented gives also a section of the inner cylindrical sac, or stomach.

The upright walls of these compartments which we have described are known in science by the name mesenteries. Of what use are they? The most obvious service they perform for the animal when erect is, as we think, the stiffening of the structure. And this is done at will, as if it were a sort of erectile tissue. Now, as the cardinal plains connect both the inner and the outer cylinder, that is, the stomach and the column, it will be seen that the efficiency in the direction of imparting strength is considerable. The column is by so much the more strengthened, as it has the more of these upright planes or septæ attached to it by one of their respective edges.

But it is in these compartments, and on the mesenteries themselves, that the origin of life for the actinia's progeny begins—for there the ova and the spermatozoa are found. On the mesentery-walls are borne in series certain reddish bands. These are the reproductive organs, and contain the ova and the spermatozoa. Generally actiniæ are what the botanists call diœcious; that is, the ova are found in an individual—that we may call the female; and the spermatozoa in one that we may in like manner call the male. As to the time, and even the method of propagation, mother actinia is very capricious, there being, so far as our observations may determine, no regularity, but at the right time doubtless, for her convenience, the actinia evicts her young. Usually these are discharged at the mouth.

They are tiny little things, clad with cilia, with which they move freely in the water for a little while, then settle on some stone, and give themselves up to a sedateness worthy the parent that gave them birth. It often happens that mother Anemone sends out her little ones in a very rough way into the world. In fact, they are introduced into actinian society sadly *sans ceremonie.* From the mesentery chambers are certain little ducts which open into the neck of the orifice, which we have called the mouth; and this orifice, it will be remembered, is directly over the open stomach. So it sometimes happens that when one actinia is sending out a litter of her babies from the mouth, she, just at that very moment, takes a notion to empty her stomach of the indigested leavings of her last meal, so that these indigesta and two score innocents are evicted in a dreadfully execrable and unmeally-mouthed manner.

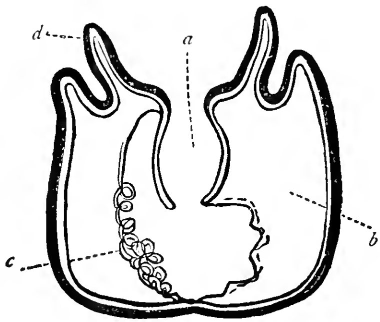



FIG. 3.—VERTICAL SECTION OF ACTINIA.—*a*. Stomach-sac; *b*, Mesentery; *c*, Craspedum; *d*, Tentacle.

We must now notice a remarkable apparatus known as the lasso-cells. It has been repeatedly observed that an actinia has a stinging, or, as it is called, an urticating power over the tissue of other animals. Now, there are in different parts of the body of an actinia innumerable cells, from which, especially the cells on the tentacles, it can dart an invisible thread. The microscope can see it, and has made known its structure. In some species this delicate thread thus shot out is a marvelously-complex affair. It is coiled up, and when necessity urges, at the will of the animal, it is darted like a cord from a spring-trap. Now, this is just the simplest part of it; for, strange to say, when this thread is shot forth, just at the striking instant, out of the sides of this invisible thread other threads or snares spring, and these last are barbed. What a wonderful mechanism is this!

Let me invite you to a sight I have many times beheld. I have in captivity a hungry sea-flower. Knowing well what suits its palate, I take a delicate morsel like a pilule, and let it fall into the water. It descends upon the waving petals, or tentacula, on the point of one of which the pretty creature has caught it in an instant. How delicate the adjustment upon its more than fairy fingers! For a few moments it is

balanced with the nicest poise on that dactylic petal. Ah! a voracious and unmannerly little bummer of a minnow sees the delicious morsel, and makes a rapid dash to snatch it from my pet. "Good! good! Well done, my bonnie!" I did not see the slightest motion of that indignant flower-creature; yet assuredly there was a movement, and an effective one, too: for the zoophyte had shot one of its invisible shafts; and the ichthyic thief dashes off like one frantic with pain. Is he hurt? Likely. His is an urticated experience. He is stung in the snout! See how he seems to shake his nose! He fairly seems to sneeze again, and actually conducts himself much like a puppy that, uninvited, has put his nose into a bowl of hot soup. Ah, ha! He is rubbing his fishy proboscis against a frond of sea-lettuce. Perhaps the salad may cool his burning pain.

Mr. Fish soon recovers his equanimity of mind; and it is observable that his deference to Mrs. Actinia since that affair has been of a decidedly distant character.

But we return to mention certain organs attached to the free edges of the mesentery-walls, those perpendicular septæ, or membranous partitions, which we have taken some pains to describe. Says Nicholson: "Along the free margins of the mesenteries there also occur certain singular convoluted cords, charged with thread-cells, and termed 'craspeda,' the function of which is not yet understood. It

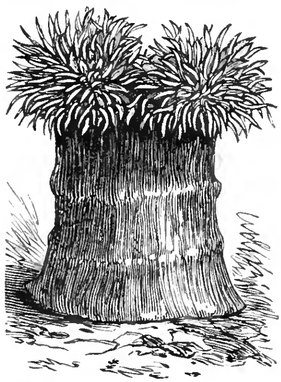


Fig. 4.—Metridium Marginatum.—Fringed Actinia (*expanded*).

is believed, however, that the apertures, termed 'cinclides,' in the column-walls of some of the *Actinidæ*, are for the emission of the craspeda." Now, some observers say that they have seen these urticating phenomena take place from the side of the column of an actinia. Is it not, then, very likely that herein is the function of the craspeda? These "cinclides," or openings in the walls of the living column, are the portholes of the little tower, whence the "craspida"-like archers launch their invisible shafts.

That is an enviable experience when one is favored with the dis-

covery of one of Nature's secrets. We recall one such made in 1858 or 1859. Though we at that time prepared an account for publication, yet it never saw the light. In order to refresh our memory, we to-day have taken from our desk this old manuscript, and given it a perusal. We had among our aquarian pets a fine fringed actinia, *Metridium marginatum*, from Newport. To our glad surprise, we noticed one day that, as it adhered to the glass side of the tank, it was surrounded by a number of tiny young ones. The question was, where did they come from? That they came from the ova I had weighty reasons for doubting. So we set ourselves to find out, if possible. One day we were watching this anemone as it was gliding on the glass. Of course, the entire base was moving. But no—that is just where we at first were in error, for there was a little speck of its base that would not go along with the rest. There that little bit of the sucking-base stuck and held its place stubbornly. The great base kept at it—pulling, as it seemed, until a mere thread-like shred of matter connected the main mass and this little stubborn, speck-like remnant. And that connecting shred stretched like a thread of India-rubber. For nearly an entire day did this sort of thing continue, when at last the shred snapped, and the one part was drawn up into the base and the other part into the adhering speck or fragment. With our pocket-lens, we watched that tiny bit which had seceded from the body politic, or rather, from which the body politic had itself withdrawn. It soon gathered itself up into a plano-convex speck. The next day we observed a depression setting in at the convex point. In a day more we detected movement. It was dividing, and there was a pulling in two directions. This did not last over a day, and there were now two specks instead of one. In about three days, at top of each, five little tentacles appeared, and a tiny mouth. Wonderful to say, each was a young actinia. And

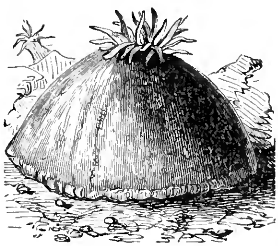


Fig. 5.—Fringed Actinia (*closed*).

how strangely begotten, too! Sloughed off—actually exscinded from the base—a veritable bit of that dear old mother; not bone of her bone, since bones she had none; but verily flesh of her flesh. This was, indeed, to us a new sort of fission. How we did watch that pair of self-made twins! Very diminutive they were, truly; but very great pets for all that.

These young actinia very rapidly increased in size, and soon had doubled the number of their feelers. Supposing that this argued an increase of feeling on their part, we found ourselves feeling an increase of interest in their ways and welfare. Just as this mutual understanding had been established, an incident occurred which filled us with anxiety. The mother-actinia began gliding back toward our little ones. That firmly-adhering base, sticking fast as the boy's sucker with which he lifts a brick, came slowly but surely, advancing toward her children. On, and on, now she is right upon them! Good-by, my twin babies, it is all-day with you now! That sucker of a mother has taken you in beyond all hope of redemption. How we did wish that that cruel parent would move on and let us see our pets again, even if dead! But no, now she would not move at all; and for nearly a day she retained that position. At length we detected movement—the gliding had begun. But, oh, how provokingly slow it was! Ah! we begin to see them at the peripheral edge of that mother's base. How flat the poor things look! No wonder, such a squeezing maternal embrace as that was. They are fairly out now—dead! dead! See, their little tentacles are protruding. It looks as if they were in a hurry to shake out their crumpled frills. Well, well, they have come out of this singular occultation as brilliantly as ever emerged a binary star.

The question whether these beautiful creatures have a nervous system seems not settled. That they manifest phenomena indicating a will, cannot be doubted. On one occasion my pets were all sulky, like "Jack in the doldrums." Every one was closed, which means it had shriveled up into a mere gelatinous lump. Each one in this condition had a disgusting look, resembling nothing so truthfully as a

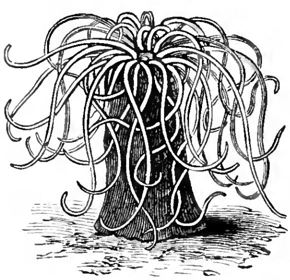


FIG. 6.—ANTHEA CEREUS (*Opelet*).

ripened boil when the fetid core is ready for extraction. And we have often seen even this repulsiveness intensified, by evolving in threads a white, stringy slime, that peculiar mucous lining of which, in parts at least, the creature often takes occasion to divest itself when in repose. (*See* cut of Fringed Actinia closed.)

As above, when in repose, these sea-anemones look like clots of gelatine, and, as many of the actinia are very small, we have known

fishermen who have handled them, when adhering to oysters, for years, and never knew that they were aught else than spots of slime. Once, when out on the shore at a very low tide, and busy overturning stones, in search of creatures thus concealed, a fisherman, wondering what we were about, came and accosted us:

*Fisherman*—"What have you got, mister?"

*Self*—"Some little sea-flowers;" and we pointed to certain little hemispheres of pellucid but limpid pearl, on a stone held in our hand.

*Fisherman*—"What! them grease-spots?"

*Self*—"Yes. And you should see them when the tide's up. Then every one opens into a little flower. They're only shut up now."

With an expression that indicated doubt of our veracity, or sanity, Piscator turned away, muttering as he left, "Guess you'd better shut up, my blossom!"

However, we took our "grease-spots" home, proud enough of them. After time given for rest they came out finely. Pretty things they were. There was one especially, over which we had both joy and sorrow—the one to have found it, and the other when it died. It was a wee but winsome thing, about a third of an inch when unfolded, and all parts of it, column, and disk, and petals, were each and all of a soft, limpid emerald. Oh, we thought, if that could be transformed into a hard substance, what a gem it would be! That was the only time we ever saw an entirely green anemone. The green opelet of Great Britain is only so as to its tentacles, and even these are tipped with red. We have often obtained from the rocks in the East River very pretty small anemones, of an orange hue.

Generally the sea-anemone will not spread her beautiful form in a bright light. Often, when all seemed sulky and there was a general collapse, we have restored the whole coterie to good-humor, simply by covering up the aquaria for an hour or two, and then uncovering, when the flowers will fully open. It was a great transformation to see, when this change took place with our favorite—a fine, large, fawn-colored *Metridium marginatum*, obtained from Newport. When in healthful expansion it was larger than a good-sized dahlia; and although of a subdued neutral tint, yet in form and color we thought our marine-flower the superior of its terrestrial rival.

Somewhere we read the lucubration of a philosopher that there was no humor in Nature, but all was serious. The observation struck us as very learned, but very silly. No humor in Nature? Nonsense! Come out from your candle-light cogitations unto some real observations in the sunny light of Nature's beaming face, and I can show you humor. Ay, fun, if you will—yes, even practical jokes. A large actinia took a notion to swallow a large scallop, which it had captured. After considerable stretching it got the bivalve down into its stomach, and in due time the contained mollusk was digested. But what about the shell? Why, this—it could not get it up again! It was a double

disaster—literally as to the scallop, and metaphorically as to the polyp: both were sadly taken in. Actinia now looked very serious—comically so—like one in an evil strait. Perhaps it felt as bad as a hen-pecked subject, for it had got itself around a pecten, and a *pecten maximus* at that. If a guest at tea should swallow the tea-saucer, matters would look alarming. And this bolted scallop was as big as a saucer. The effect upon the actinia's looks was ludicrous, since there was a narrow, bulging, equatorial belt, strongly significant of an undue centrifugal force in activity at that place. Get rid of the saucer it could not; so it seemed, with a saucy air, to have made up its mind to resort to an expediency that should fairly checkmate the strange exigency. And this expediency was a change of base. In fact, it transformed its old base entirely. Tentacles grew out around it, an oval aperture appeared, and, in a word, it became a double actinia, and the large scallop shell was made a double base, and was accepted ever after as the demarcation of the two individualities. No fun in Nature? If this, despite a smack of sauciness, was not a practical joke of the first water, then bring out your specimen-brick, old Sober-sides!

But the time is up, and so much must be left unsaid. In the cuts is the white Arachnactis, a baseless actinia, which, stuck in the mud, waves its few snaky tentacles about. And there is the waxy Anthea, or opelet, with its snaky or gorgon hair. But we must stop, without telling of the singular varieties of forms, and the rich diversities of tint and color, and the sometimes queer, yet normal functions performed by these marine animal mimics of the floral structures of the land.

# THE FIRST TRACES OF MAN IN EUROPE.

By Prof. ALBRECHT MUELLER.

TRANSLATED FROM THE GERMAN, BY PROF. JOSEPH MILLIKIN.

## II.

We have been concerned heretofore with the human and animal remains of the older Diluvium. We come now to the upper and more recent layers of that formation.

In these, the formerly so abundant remains of the cave-bear are wholly wanting, those of the mammoth very rare. The common animals are the giant-elk, primitive ox, aurochs, horse, chamois, steinbok, moose, monkey, and various species at present confined to arctic and high Alpine and Pyrenean tracts. The characteristic animal of the time, however, is the *reindeer*, heretofore absent or very rare, and hence the name—the Age of Reindeers.

The continued prevalence of a northern and Alpine fauna in the

lowlands of Europe, proves the continuance of the severity of climate; we are still dealing with the Ice period, or probably with a second ice-period, as many infer from the peculiarities of the more recent drift. Of course the retreat of the glaciers of this later Ice period—glaciers apparently less in mass and extent than those of the former one—would produce fresh floods and all the phenomena previously explained as the results of such floods.

Men were still troglodytes, but also to some extent lived out-of-doors in so-called *stations* at the foot of sheltering cliffs. The domestication of animals was not yet practised, even the reindeer being used for food only, though this is disputed by some writers. Of the use of metals there is not a trace. This age is shown by every indication to be separated from our own, the historic age, by not less than 10,000 years, as to its initial point, at least, for some writers believe it to have been continued until the beginning of historic times.

The knives, axes, and spear-heads, are still rough-worked, but more carefully and skillfully than before. The material for them was brought from considerable distances; those found in Belgium, for instance, being made from flint-bowlders found in the chalk of the Champagne district. Very many kinds of implements were in use. The pieces of iron-stone found among them were probably used there, as they are now, by many tribes, for painting the face and figure. Bright stones, shells, and the teeth of animals, were perforated and strung into necklaces and bracelets—personal vanity thus anciently asserting itself. Skins and furs were used for clothing. Needles of horn and bone, and pieces of horn and stones manifestly used for smoothing down the seams, are often met with. The dead were buried at full length in caves.

The station at Solutré, department of Saône-et-Loire, is rich in memorials of this remote age, such as carefully-wrought articles of flint, and bones of the species named, especially of the reindeer; and near by is a burial-cave in which are several perfectly-preserved skeletons, with skulls of the Mongol type, according to Dr. Pruner Bey. In this instance the bodies of the dead were inclosed between flag-stones.

Pottery had now come into use, but it was roughly made by hand and unburnt. The beginnings of art are now met, as in pictures upon bone, ivory, and slate, of the mammoth, aurochs, horse, etc., and even sketches of the human figure. In some of these drawings, shadows are rudely but not badly shown by peculiar linings. At Bruniquet, also, in the department of Tarn-et-Garonne, such engravings of the mammoth and reindeer have been found.

One of the most interesting collections of relics of this age was found in the Station de la Madeleine, in the department of Dordogne. Bones and flints from another locality seem to show the marks of an iron hammer.

The cave of Cro-Magnon, in the same department, was rich in human skulls, skeletons, and handiwork; among other articles were perforated shells, evidently once worn in necklaces. Contrary to rule, bones of the mammoth were here associated with those of the reindeer.

At Chavaux, Belgium, was a deposit of remains, the disposition and other indications of which almost compel the belief that the place was the scene of a cannibal feast. The human skulls and bones are all of young women and boys, witnessing to a decided preference for young and tender flesh on the part of our anthropophagic ancestors. These bones were split open longitudinally, as was the custom with those of animals, for the extraction of marrow. This and similar discoveries in other caves throw a singular light upon the habits and culture of the men of this time.

Many Belgian caves, and notably that of Chaleux on the Lesse, yield large collections of mammal bones and stone implements.

The digging of a mill-race through a peat-bed at Schussenried, a village not far from Ravensburg, revealed a station very rich in archæological relics of this age. It was probably little more than the rubbish-heap of a station near at hand. There was here a profusion of flint articles, and bones and antlers of the reindeer. The mosses and snail-shells of the peat of this vicinity belong, like the mammals mentioned, to arctic and Alpine species, and are thus another evidence of the rigors of the climate of that time.

A station at Salêve, near the Swiss frontier, contains reindeer-bones of the Reindeer age, and stone axes, and human bones of the preceding Age of Mammoths.[1]

Switzerland and the Rhine valley below Basle have furnished but few relics of the Reindeer age, while France has many localities yielding quantities from both this and the Mammoth period, which are the two earlier Stone ages, the third and last of which will be next discussed.

So far, we have found human bones, skulls, skeletons, axes, knives, spear-heads, needles, ornaments, etc., of the periods discussed, in almost every country of Europe—in Greece, Italy, Spain, Portugal, and the soil of classic Rome itself, as well as in the northern regions.

The Age of Polished Stone.—This name has been given by French writers to the third era of prehistoric human existence, on account of the characteristic smoothness and polish of the stone implements.

The distribution of land and sea, the relief of the surface, the climate, and the flora and fauna of this age, were substantially as they are now.

Among its oldest memorials—and the age probably ended about

[1] After a new and critical study of this deposit, Prof. Rütimeyer believes it to be a confused mingling of remains from various epochs.

B. C. 5000—are the Kjökken-mödding[1] of Denmark, found at stations adjacent to the sea, and consisting of immense collections of empty mussel and oyster shells. Similar heaps are found in the United States.[2] The late Prof. von Mulot made careful studies of those of Europe, and the reader is referred to his valuable works for details. Comparatively barren as we have stated Switzerland to be in human memorials of the two preceding eras, it is the land richest in those of this age; for to it belong the oldest of the pile-dwellings found in most Swiss lakes and lacustrine peat-beds.

They were first discovered at Meilun, on Lake Zurich, during the winter of 1834–'35, when the level of most Swiss lakes was exceptionally low. Of course the mere existence of piles in our lakes had long been known to fishermen, but their real meaning and their significance for science was there first recognized by that keen-witted observer, Dr. Ferdinand Keller, of Zurich. We can offer nothing like an adequate description of these remarkable lake-villages, and shall speak of them only with reference to the indications they afford as to the man of this as compared with that of former prehistoric periods.

In addition to the rough-worked implements heretofore so abundant, we now have smooth, even polished axes, etc., of various hard stones, especially of greenstone, a term including diorite, syenite, and the peculiar serpentine which the Italians call *gabbro.* These axes were in various ways, and sometimes very ingeniously, attached to bone, wood, or horn handles. Besides these larger articles are many smaller ones, made of wood and horn, with arrow-tips and spear-heads of flint, jasper, and rock-crystal, often made with remarkable skill and carefulness of finish.

With the Age of Reindeers ends the Diluvial period proper, of which most of the characteristic animals, the reindeer among them, were by this time extinct, or else had wandered to distant regions. Hence the absence of their remains in later formations. Evidences of the domestication of animals now appear for the first time. Pottery is still rude and unburnt, but ornamented with odd stripes and rows of dots. The pieces are mostly conical, the bottom being the truncated point. No trace of writing, drawing, or sculpture, is to be found—a fact the more remarkable in view of the existence of the works of art mentioned as belonging to the preceding age.

The literature of the pile-dwellings is already quite extensive. Keller, Desor, Troyon, Morlot, and others, have written valuable manuals, while Heer and Rütimeyer have given *in extenso* the results of their thorough study of the vegetable, animal, and human remains, found in these curious habitations.

Those of the age we are considering are found in the edges of many

[1] Literally, *kitchen-refuse-heaps.*—TRANSLATOR.

[2] They were capitally described in the *American Naturalist* for January, October, and November, 1868.—TRANS.

lakes, and in peat-bogs near Pfeffikon, Inwyl, Wauwyl, and Moosseedorf. Often they are grouped into considerable villages, as on Lakes Constance, Neuchâtel, Geneva, Zurich, and Morlat. These dwellings are found not only in Switzerland, but also in Bavaria, Carinthia, Moravia, Pomerania, and Mecklenburg, in Germany; and in France, England, Ireland, and the north of Italy. Of these some belong to the Stone age, some to the Bronze age, which we will next describe, and some were inhabited during both the Stone and Bronze ages.

With the pile-dwellings are to be classed the cranochs or cranogues—artificial islands, built upon piles in the peat-bogs and lakes of Ireland; the burial-places of Monsheim, near Worms; and land-stations in wellnigh every country in Europe, as well as in Asia Minor, Syria, Palestine, Japan, Java, India, North Africa, Egypt, and North America. It must not be forgotten, however, that the polished-stone implements of some of these various localities may belong to later times, as there are now living tribes at about the grade of culture that was attained in the Stone age.[1] At Grand-Presigny, south of Tours, and at Charbonnières, in the Mâcon district, are places abounding with the nuclei of flint-boulders, and articles made therefrom in every stage of finish, with many spoiled in making—places evidently once devoted to this manufacture. Some caves in the departments of Yonne and Ariége show layers of loam upon calcareous tufa, the human and animal remains of each of which are exactly those of the successive ages we have discussed, viz., of the Mammoth, of the Reindeer, and of Polished Stone. That is, they constitute a succession of deposits, each with its peculiar animal remains, and hence offer the same kind of evidence as to their relative antiquity as do the older geological strata.

And like the earlier geological eras, the various ages of prehistoric human existence are not sharply defined and severed, each from the preceding and succeeding one, but one merges into the other by gradual progressions of thousands of years. Not only certain species of plants and animals, but entire races of man, have thus slowly vanished from off the earth, or retreated to lands far remote, while others have as gradually come in to occupy their places. Some animal species, as for instance Speller's *Borken-thier*,[2] the dodo, and the auk or great diver, have died out within historic times; others in very recent times, as for example the huge birds of New

[1] Long after metals were in common use among them, many ancient peoples (of which the Jews were one, as the Bible informs us) employed stone knives in all religious sacrifices, etc. The Indians of North America and the Greenlanders yet use stone implements exactly similar to those of the lake-dwellings.

[2] Literally, *bark-animal*, or bark-eater, as we would say in English. I am utterly at a loss for the English or scientific synonym. The best guess I can offer is that it is a Castoroid, or Castor proper—possibly the giant beaver of the species *Discopylus*. (*See* Dana, "Geology," pp. 562, 563.)—Trans.

Zealand and Madagascar.[1] And there is going on before our eyes the sad spectacle of the extinction of some of the nobler savage races of men, incapable of persistence in life in an age like ours, opposed by the superior forces of European civilization.

From the beginning civilization has spread from the East to the West, and such is still its line of march, as illustrated by the Teutonic race's steady pressure into the ever-receding "far West." So, too, with the people of the pile-dwellings. They probably came from Asia to Europe some 6,000 or 7,000 years ago, being doubtless affected, as is every people, by the powerful modifying influences either produced or put in full play by such long and vast migrations. And the people who made the stone axes and the pile-dwellings is probably the same that reared the huge funeral piles known as *dolmens*.[2] A dolmen consists of two immense blocks of stone placed on end,[3] upon which a third is laid, forming a sort of table. The dead were buried beneath, with various implements and weapons at hand. How a people, without engineering skill and contrivances, could rear such masses into position, is a problem yet unsolved. They are found in Brittany, Southern France, Great Britain, Portugal, North Africa, Nubia, Palestine, and the East Indies, those of Brittany being the largest.

Thus, instead of the golden age, that fancy represents as lying far back in the race's childhood, we find the dull realities of a long Stone age, during which man endured all and more than all the perils and sufferings of the present.

And yet, for each of us, as years steal over us, the days of our own vanished youth are ever "the *good* old days."

THE AGE OF BRONZE.—The predominance of bronze, as the material of the articles found in the later pile-dwellings, has given to the fourth prehistoric human epoch its name—the Age of Bronze. While some of these lake-villages continued in use from the Stone age, others —usually those farthest out in the lakes—evidently originated in the Age of Bronze.

There is no longer room to doubt that the bronze articles of Switzerland were made near the places of their discovery, and were not brought from the East, according to the common view. Some of the very moulds in which they were formed have been discovered, and at Nantes the remains of a foundery have been plainly made out. Whether the bronzes of Northern Europe are of Phœnician origin is yet in doubt. Their symbolisms and religious adaptations are in favor of that view.

[1] To wit, the dodo, solitaire, moa (*Dinornis giganteus*), and *Æpiornis maximus*. (For description, *see* Dana, pp. 578, 579.)—TRANS.

[2] Or cromlechs.

[3] In some instances there are three or more uprights. The covering stone of one specimen is 18 feet long by 9 broad. In the Anglesea cromlechs are stones weighing 30 tons each.—TRANS.

The native origin of those of Switzerland is settled by the analyses of Prof. von Fallenberg; for, whereas the metal of Phœnicia, Egypt, and the East generally, contains lead in considerable quantities, that of Switzerland is of tin and copper only. So much artistic taste and mechanical skill are shown in these various articles—needles, rings, armlets, etc.—that many of them might be used by modern ladies without discredit to their work-boxes or toilets. But, in singular contrast to the Stone age, there is no relic of any portrayal of man or beast or plant. We meet, for the first time, with pottery turned on the lathe and well burned. Instead of dolmens we now have mounds, in which the dead are laid at full length, with weapons and ornaments by their side. Some localities offer indications that the burning of the dead was practised. Here belong the so-called Celtic mounds, and the Terremare or Emilian mounds near Parma abound in relics of this age. Rütimeyer and others show that, although the characteristic animals of this and the preceding age are identical as to their species, in this age the domesticated animals predominate, another evidence of advancing culture.

We may ascribe the introduction of bronze manufacture into Europe to a great race immigrant from Asia some 6,000 years ago, called *Aryas* or *Aryans*. And this Bronze age reaches to and overlaps the beginning of the historic period in some countries, and so includes the great epochs of the Assyrian and Egyptian Empires (B. C. *circa* 1500), and the earlier eras of the next succeeding Age of Iron.

The Age of Iron.—The nearer we approach the present, with its rapid growths and changes, the shorter become the several ages into which we divide the history of man as to his physical surroundings and peculiarities, and the successive grades of spiritual and social development through which he has passed.

Last of the prehistoric eras is the Age of Iron, represented in some of the pile-dwellings and their contents, but best, and with least admixture from earlier and later times, in the station of La Tène on Lake Neuchâtel. This age considerably overlaps the historic period of several countries. We can but mention some peculiarities of its earlier portions.

In the determination of its initial and terminal points we must remember that the civilization of the East preceded that of the West by several centuries. There are many proofs that a considerable degree of culture existed at its very beginning. Mounds were still used for burial. Bronze, also, was yet in use, but iron as well. Pottery was now not only shaped on the lathe, but burned a good red. Manufactures in glass, gold, and silver, are found for the first time. In lonely mountain-places are yet found dross and the remains of iron-furnaces of the time. To be sure, this dross is sometimes ascribed to volcanic action, but it is met with where volcanoes never could have existed.

To the former part of this age belong the weapons found in the Tiefenau, near Berne, plainly indicating that it was the field of a battle fought some 600 years B. C. Of great interest, also, is the ancient city of graves near Hallstadt, where the Burgomaster Ramsauer and others found over 900 graves and an immense quantity of iron and bronze weapons. But, interesting as such discoveries are, they lie too far outside the special topic of our treatise to be further discussed.

If a name, descriptive of the age in which we live, be sought for, "the Age of Paper" is perhaps as good as any that can be discussed. If we name it not from its present but its near future characteristic, we may perhaps best adopt that suggested by an eminent geologist—"the Age of Steel."

Even this hurried retrospect of the various prehistoric ages makes prominent the fact that in Europe, if not over all the earth, humanity has progressed, with various temporary haltings, from beginnings very rude and, in some respects, almost animal-like—that it is only after the lapse of many millenniums it has attained its present high physical and spiritual development.

In the progress of these studies we have perhaps become the poorer by more than one fair dream's evanishing. We have not found—we could not find—either the lovely paradise of our first parents, nor the much-sung, much-blessed golden age.

But one thing, at least, such investigations secure to us—the conviction, namely, of the limitless perfectibility implanted by the Creator in the very germs and essence of all his creatures, and preëminently in man.

And this conviction it is that opens to the eye and hope the precious, the inspiring prospect of an ever richer, fairer development for races yet to come.

## SCIENTIFIC PROPHECY.

PROPHECY is the prediction of an event—the declaration of something to come. When future events—either in the history of the world or in the life of man—have been foretold from no known data and from no law, the prophecy must have been divine, for none but God can know the future of man. When such events in the history of Nature and in the life of matter have been predicted from known data and from established laws, the prophecy is human and scientific. Every science in its growth passes through three stages: First, we have the stage of observation, when facts are collected and registered by many minds in many places. Next, we have the stage of general-

ization, when these well-ascertained and carefully-verified facts are arranged methodically, generalized systematically, and classified logically, so as to deduce and elucidate from them the laws that regulate their rule and order. Lastly, we have the stage of prophecy, when these laws are so applied that events can be predicted to occur with unerring accuracy. Astronomy is said to be the only science which has thoroughly reached the last stage. Other sciences are in various stages of growth. Electricity in some branches has reached the third stage, but in many branches it is still in its infantine period. Astronomy predicts eclipses, transits, occultations, for any period in the future, and the "Nautical Almanac" is the most wonderful example of prescient knowledge: a sailor may go away for a five years' cruise, and yet in this book he will find every event in the motion of the planets, the movements of the tides, the rotation of the moon, the eclipses of the sun, etc., faithfully and unerringly foretold. But astronomy has produced greater wonders than these. The planet Uranus was found to suffer from some slight disturbances in her path round the sun. Adams in England and Leverrier in France simultaneously and independently, from the known laws of gravity, predicted the existence and position of another unknown planet. Galle, of Berlin, directed by Leverrier, found the planet in the spot indicated, and it was called Neptune.

Newton, the grandest scientific man the world has perhaps ever seen, and the founder of the laws that led to the prophecy just narrated, in his investigations on light, predicted the fact that the diamond was formed of some combustible material—from its very high index of refraction. The combustion of diamond is now an ordinary, though expensive, lecture experiment. Light has given us one or two other scientific prophecies. Poisson, from theory, pronounced that, in the case of an opaque circular disk, the illumination of the centre of the shadow caused by diffraction at the edge of the disk would be precisely the same if the disk were altogether absent. Arago proved this to be true. Again, Sir William Hamilton predicted that in biaxial crystals there were four points where the refraction of the crystal upon an incident ray produced a continuous conical envelope. Dr. Lloyd took a crystal of aragonite, and, following Hamilton's directions, discovered what the mathematician had predicted.

Whewell predicted from theory that there must be a certain point in the North Sea, midway between Lowestoft and the coast of Holland, where there was no rise or fall of the water, because the crest or high-water mark of the tidal wave, and the trough or low-water mark of the same wave, reached the same point at the same time, but by different routes. Captain Hewett, R. N., found that it was so.

Electricity has its prophets. Faraday, examining Sir Charles Wheatstone's beautiful experiment on the velocity of electricity by means of a rotating mirror, said: "If the two ends of the wire in

Prof. Wheatstone's experiments were immediately connected with two large insulated metallic surfaces exposed to the air, so that the primary act of induction—after making the contact for discharge—might be in part removed from the internal portion of the wire at the first instant, and disposed for the moment on its surface jointly with the air and surrounding conductors, then I venture to anticipate that the middle spark would be more retarded than before. And if those two plates were the inner and outer coatings of a large jar or Leyden battery, then the retardation of the spark would be much greater." The experiment was not made for sixteen years. It was then shown as the explanation of the retardation of the current in our subterraneous and submarine wires.

Sir Francis Ronalds, with wonderful prescience, had in 1823—fifteen years before Faraday—suggested "the probability that the electrical induction which would take place in a wire inclosed in glass tubes of many miles in length (the wire acting like the interior coating of a battery) might amount to the retention of a charge, or at least might destroy the suddenness of the discharge." Faraday's prophetic vision and Ronalds's far-sighted knowledge are verified in every working cable. The accuracy with which our cable-repairers are directed by our electricians to the spot where the wire is broken, the exactitude with which the working speed of a cable is predicted, the unfelt and invisible supervision which is exercised over the care and maintenance of our telegraphs—even though they pass through distant countries and different climes—are evidences that electricity, in this particular field, is approaching the last and prophetic stage of its growth. This field is resistance, and Ohm is its prophet.—*Telegraphic Journal.*

## THE CHEMICAL RADIATIONS.

By W. J. YOUMANS, M.D.

WITH that proneness to go wrong, which we notice in most things human, and which crops out in science as well as elsewhere, the art of making pictures by the chemical action of radiant forces has got a false name. This is all the worse, as it was at first correctly designated, and that too by him who had the clearest right to give the process a title. Davy and Wedgwood, early in the century, had labored to produce sun-pictures by means of the *camera-obscura*, but had met with little success. In 1814 M. Neipce, of Chalons, in France, took up the subject, and, in the course of ten years' assiduous work, he succeeded in a method of forming sun-pictures on chemically-prepared copper, pewter, and glass plates, by which the lights, semi-tints, and shadows, were represented as in Nature, and he also succeeded in

making the impressions lasting. In 1827 he sent a paper to the Royal Society, accompanied with specimens; but, as he kept the process a secret, the communication could not be received. The process, however, he named *heliography*, or sun-drawing, a term by which it was truthfully characterized. M. Daguerre, another Frenchman, had been working at the same problem, and in 1829 these two men, with a common purpose, formed a partnership to carry on their researches jointly. Neipce died before the work was matured, and Daguerre, very naturally, reaped the honor of it. The French Government bought his secret, paying with a life-pension, and promulgating it to the world, without restriction of patent, in August, 1839. The new pictures were at once known as *daguerreotypes*, and the mode of making them the *daguerreotype process*. These uncouth terms endured for a while, but were at length supplanted by the word *photography*, or *light-drawing*, which has become established. Yet the appellation is incorrect, and the error is as broad as the difference between light and darkness. It is not light that makes the picture, but dark radiations that are associated with it, and that have the peculiar effect of producing changes in certain chemical compounds.

Although photography, in its wonderful development as an art, belongs to the past generation, yet the knowledge of the chemical effects ascribed to light is as old as chemical science. The subject began to be inquired into, experimentally, about 100 years ago. In fact, like most other modern chemical results, it had not escaped the notice of the alchemists, but, like every thing else they discovered, it was subordinated to their mystical speculations. In the multiplicity of their manipulatory processes they stumbled upon a combination which they called *luna cornua*, or horn-silver, and which is now known as silver chloride. The alchemists knew nothing of its composition, but only that there was silver in it which had undergone a change. They noticed, however, that when this horn-silver was exposed to light it underwent a blackening, and, as they taught that "silver only differed from gold in being mercury interpenetrated by the sulphurous principle of the sun's rays," they concluded that this change, effected by light, was the commencement of the process by which silver was to be transmuted into gold.

It was in 1777 that the illustrious Swedish chemist, Scheele, published the first results of investigations upon the subject undertaken simply for the extension of chemical knowledge. He found that, when powdered *horn-silver* is spread over paper, and the colors of the solar spectrum are made to fall upon it, the powder in the violet ray turns black sooner than that exposed to the other colors. Senebier afterward showed that the silver chloride was darkened in the violet ray in fifteen seconds to a shade which required the action of the red ray for twenty minutes; that is, the chemical intensity of the violet ray was eighty times greater than the red.

The next step was one of great scientific importance, indicating, not only the differentiation of the different modes of action in the sunbeam, but the actual separation and isolation of the different agents. This took place just at the opening of the present century. It was shown by Sir William Herschel, in 1800, that, when the sunbeam is decomposed by a glass prism, as shown in Fig. 1, the heat is distrib-

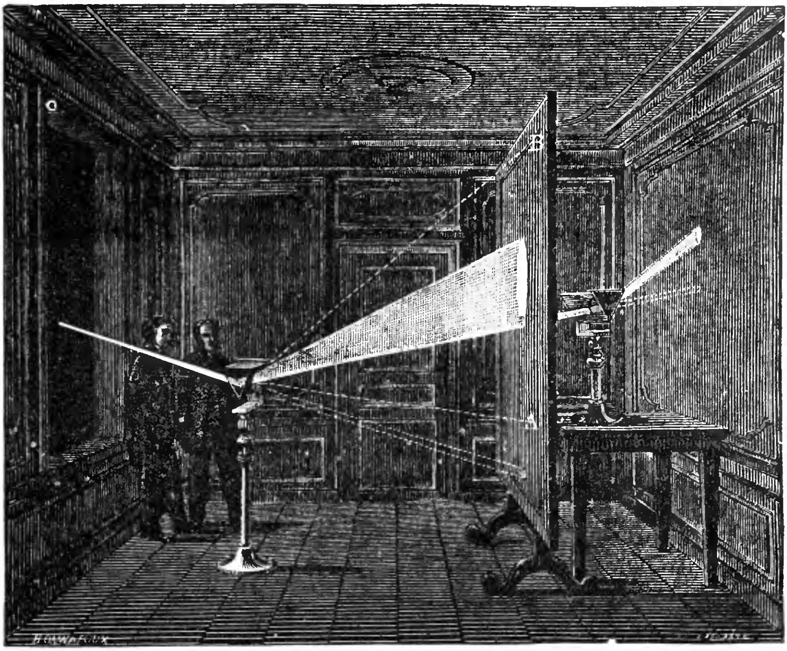


Fig. 1.—Positions of the Three Spectra.

uted unequally through the series of colors—is lowest in the violet, increases in the yellow, but is most intense in the red. This he determined by the use of delicate thermometers, and, in the same way, he proved that the thermal rays of the sunbeam are not all thrown into the visible spectrum, but are of such low refrangibility that they accumulate in the dark space below the red. There is therefore a spectrum of dark rays, producing heating effects, which, beginning at *A*, Fig. 1, increases in strength till it approaches the red, and then fades away in the upper region of the spectrum.

These results of Herschel were followed by the discovery of Ritter, made the next year (1801), that the chemical rays, which had been shown to be most active in the violet portion of the spectrum, were also thrown by refraction into the dark space beyond the violet. As a thermometer was the test in the case of heat, so an appropriate chemical substance has to be used to test the distribution of this force.

If a solution of silver nitrate is washed over a large sheet of paper, which is then placed upon the wall or screen so as to receive the spectrum upon its surface, and is also made to cover the space considerably above it, a transformation occurs where the radiations fall, producing a blackening which defines the outline of the chemical spectrum. It is now found that the chemical rays are more refrangible than the luminous, and that, while the darkening takes place in the colored spectrum, it it strongest in the violet of all the colors, and extends also through the dark space up to *B*, as shown in the figure.

It is now exactly 200 years since Newton published his "Optics," in which was described the capital experiment of resolving white light into its constituent colors by the prism. It was the first great step toward showing that what was regarded as perfectly simple turns out to be inexhaustibly complex; and every succeeding step of research, while clearing up some points, has led to others which are still unresolved. One thing, however, seems to be quite clear: the mode of action throughout the spectrum is fundamentally the same. There are three spectra, one of which, the thermal, takes action upon all kinds of matter; another of which, the luminous, acts only upon a certain special form of nerve-matter; while a third, the chemical, produces changes in certain compounds. Although the luminous force acts only upon the nerve of the eye to stir up a sensation, yet we know how infinitely complex and varied is the world of color that results. There is evidence that the dark thermal and chemical radiations are of equal variability and complexity, yet there can be no doubt that all these multitudinous effects are due to a single mode of action. The difference between the thermal and the chemical rays is simply the difference between the red and the green; that is, a difference of wavelength and degree of vibration.

The unequal distribution of the forces of the spectrum is well illustrated by Fig. 2. The middle curve shows the varying intensity of the luminous force. The maximum is at *B*, in the yellow space; and from this point the intensity of the light rapidly declines each way, its extent being shown by the space shaded with oblique lines. The curve *A*, with the vertical lines, represents the position and varying force of the heat; and the curve *C*, horizontally shaded, exhibits the distribution and unequal energy of the chemical force. The three maxima are widely separated as if there were some antagonism among them, and it is noticeable that where the light is strongest the chemical force quite disappears. Different prisms give somewhat different effects but do not change their order.

It thus appears that, so far from light being the agent which produces sun-pictures, the intensest light is powerless upon the chemically prepared plate. It looks as if the illumination neutralized or extinguished the chemical energy. Nevertheless, light and the chemical force are so intimately associated in reflection and refraction that

the colors become the guides of the artist in conducting his processes. When a person sits before the operator's camera, ready to be "taken," the radiations which are reflected from his face into the instrument, and collected to a focus by the lens, form three pictures, one behind the other, the thermal, the luminous, and the chemical image. The luminous image is visible upon the ground-glass plate, giving all the

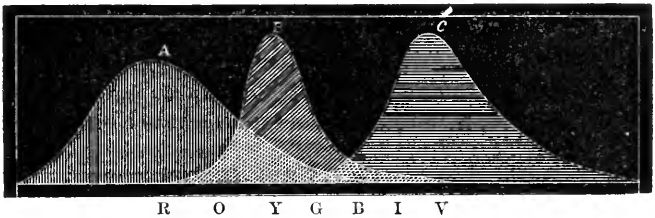
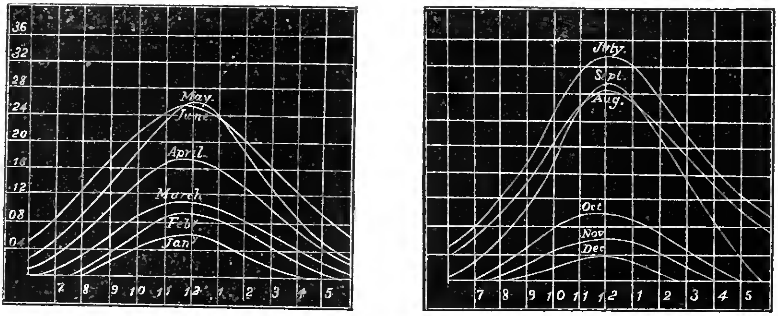



FIG. 2.—INTENSITIES OF THE FORCES OF THE SPECTRUM.

colors of the object, but the chemical image is now blurred, and the focus has to be readjusted so that the chemical picture will be clearly and sharply defined; but, as this image is invisible to the operator, he has to make his readjustments by rule. As he cannot reproduce the colors in the photograph, he has to substitute for them tints and shades; but the chemical force is so unequal in the different colors that the natural effects of gradation in tone and shade are not brought out in the picture. This is one of the embarrassments of the process. From the representation in Fig. 2, we should infer that blue colors would act energetically upon the photographic plate and the yellow and red feebly, or not at all, because the chemical rays abound in the former and are absent in the latter. Of this false working of lights Prof. Vogel says: "Blue generally works clear, yellow and red work like black. The yellow freckles appear, therefore, in a picture as black spots, and a blue coat becomes perfectly white. Dark-blue flowers on a light-yellow ground produce in photography light flowers on a dark ground. Red and also fair golden hair become black. Even a very slight yellow shade has an unfavorable effect. A photograph from a drawing is often blemished by little iron-mould specks in the paper, invisible to the eye. These specks frequently appear as black points. There are faces with little yellow specks that do not strike the eye, but which come out very dark in photography. A few years ago a lady was photographed in Berlin whose face had never presented specks in photography. To the surprise of the photographer, on taking her portrait, specks appeared that were invisible in the original. A day later the lady sickened of the small-pox, and the specks, at first invisible to the eye, became then quite apparent. Photography in this case had detected, before the human eye, the pock-marks, very feebly tinged yellow."

The chemistry of light first became, in the full sense, a branch of science capable of thorough investigation when Dr. Draper devised a method of measuring the force of the chemical rays, and thus brought the subject within the sphere of quantitative research. He showed that these rays are absorbed in the chemical combination, and that the rate of absorption corresponds to the amount of chemical change. He applied mixtures of chlorine and hydrogen gases for this purpose, which combine under the action of the chemical radiations, the measurable rate of combination becoming the index of radiant activity. Professors Roscoe and Bunsen subsequently employed sensitive papers, which were blackened in certain times to certain shades, as measurers of the chemical force, and these were used at the Kew Observatory,

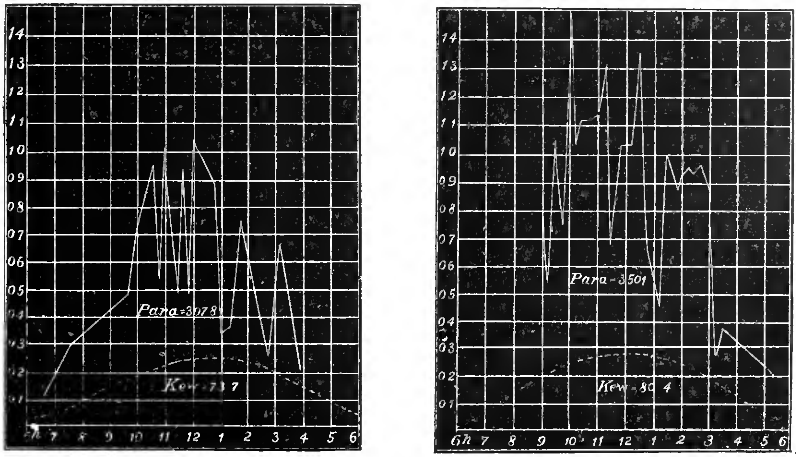



FIGS. 3 AND 4.—VARIATION OF CHEMICAL RAYS AT KEW.

near London, to trace the variations of chemical activity in the solar rays. For, as the chemical force is not light, neither does it follow the laws of light in producing its effects. Dr. Draper had previously shown that, as we go southward toward the equator, and the light increases in brilliancy, there is an increasing interference with the chemical rays, the yellow space of no-chemical action widening with the progress southward. It is also well known that there is much greater difficulty in obtaining good photographic pictures under the full blaze of a tropical sun than in our own latitude. The investigations at Kew were accordingly directed to the variations that the chemical rays undergo at different hours of the day and at different seasons of the year. The graphic diagrams, Figs. 3 and 4, show the results that were arrived at in 1866. The curves exhibit the rise and fall of the average monthly chemical intensity with the hour of the day, from 6 A. M. to 6 P. M., throughout the year. We see from these curves that the maximum of chemical action occurs at twelve o'clock, and that the forenoon rise and afternoon decline are very nearly equal, while the chemical intensity of July is fully seven times as great as in December.

The statements that have been made that in Mexico, where the light is very intense, from twenty minutes to half an hour is required

to produce photographic effects which in New York require only a minute; and the further statement of travelers, engaged in copying the antiquities of Yucatan, that they frequently have been obliged to abandon the use of the camera, and take to their sketch-books, have led to some investigations, similar to those at Kew, for determining the intensity of the chemically-active rays in the tropics. Prof. Thorpe experimented at Pará, situated nearly under the equator, in the northern province of the Brazils, and lying on a branch of the Amazon. Of the results, Prof. Roscoe remarks: "Owing to the rainy season having commenced when the experiments were made, the changes in the chemical intensity, as observed from hour to hour, and even from minute to minute, are very sudden and remarkable; this is well shown by the zigzag lines of Figs. 5 and 6; and these, compared with the dotted lines below, indicating the corresponding action on the same




Figs. 5 and 6.—Variation of Chemical Rays in the Tropics.

day at Kew, show the enormous variation in chemical intensity which occurs under a tropical sun in the rainy season. Regularly every afternoon, and frequently at other hours of the day, enormous thunder-clouds obscure the sky, and, discharging their contents in the form of deluging rain, reduce the chemical action nearly to zero. The storm quickly passes over, and the chemical intensity rapidly rises to its normal value. By comparing the curves for Pará and Kew on the same days, we obtain some idea of the energy of chemical action at the tropics, and it is at once evident that the alleged failure of the photographer cannot at any rate be ascribed to a diminution in the sun's chemical intensity, which, in the month of April, 1866, was nearly seven times as great at Pará as at Kew."

# ON SOME OF THE RESULTS OF THE EXPEDITION OF H. M. S. CHALLENGER.

By Prof. THOMAS H. HUXLEY, F. R. S.

IN May, 1873, I drew attention, in the pages of this *Review*, to the important problems connected with the physics and natural history of the sea, to the solution of which there was every reason to hope the cruise of H. M. S. Challenger would furnish important contributions. The expectation then expressed has not been disappointed. Reports to the Admiralty, papers communicated to the Royal Society, and large collections which have already been sent home, have shown that the Challenger's staff have made admirable use of their great opportunities; and that, on the return of the expedition in 1874, their performance will be fully up to the level of their promise. Indeed, I am disposed to go so far as to say that, if nothing more came of the Challenger's expedition than has hitherto been yielded by her exploration of the nature of the sea-bottom at great depths, a full scientific equivalent of the trouble and expense of her equipment would have been obtained.

In order to justify this assertion, and yet, at the same time, not to claim more for Prof. Wyville Thomson and his colleagues than is their due, I must give a brief history of the observations which have preceded their exploration of this recondite field of research, and endeavor to make clear what was the state of knowledge in December, 1872, and what new facts have been added by the scientific staff of the Challenger. So far as I have been able to discover, the first successful attempt to bring up from great depths more of the sea-bottom than would adhere to a sounding-lead, was made by Sir John Ross, in the voyage to the arctic regions which he undertook in 1818. In the Appendix to the narrative of that voyage, there will be found an account of a very ingenious apparatus called "chlams"—a sort of double scoop—of his own contrivance, which Sir John Ross had made by the ship's armorer; and by which, being in Baffin's Bay, in 72° 30′ north, and 77° 15′ west, he succeeded in bringing up from 1,050 fathoms (or 6,300 feet), "several pounds" of a "fine green mud," which formed the bottom of the sea in this region. Captain (now Sir Edward) Sabine, who accompanied Sir John Ross on this cruise, says of this mud that it was "soft and greenish, and that the lead sunk several feet into it." A similar "fine green mud" was found to compose the sea-bottom in Davis Straits by Goodsir in 1845. Nothing is certainly known of the exact nature of the mud thus obtained, but we shall see that the mud of the bottom of the antarctic seas is described in curiously similar terms by Dr. Hooker, and there is no doubt as to the composition of this deposit.

In 1850 Captain Penny collected in Assistance Bay, in Kingston Bay, and in Melville Bay, which lie between 73° 45′ and 74° 40′ north, specimens of the residuum left by melted surface-ice, and of the sea-bottom in these localities. Dr. Dickie, of Aberdeen, sent these materials to Ehrenberg, who made out [1] that the residuum of the melted ice consisted for the most part of the silicious cases of diatomaceous plants, and of the silicious spicula of sponges; while, mixed with these, were a certain number of the equally silicious skeletons of those low animal organisms, which were termed *Polycistineæ* of Ehrenberg, but are now known as *Radiolaria*.

In 1856 a very remarkable addition to our knowledge of the nature of the sea-bottom in high northern latitudes was made by Prof. Bailey, of West Point. Lieutenant Brooke, of the United States Navy, who was employed in surveying the Sea of Kamtchatka, had succeeded in obtaining specimens of the sea-bottom from greater depths than any hitherto reached, namely, from 2,700 fathoms (16,200 feet) in 56° 46′ north, and 168° 18′ east; and from 1,700 fathoms (10,200 feet) in 60° 15′ north, and 170° 53′ east. On examining these microscopically, Prof. Bailey found, as Ehrenberg had done in the case of mud obtained on the opposite side of the arctic region, that the fine mud was made up of shells of *Diatomaceæ*, of spicula of sponges, and of *Radiolaria*, with a small admixture of mineral matters, but without a trace of any calcareous organisms.

Still more complete information has been obtained concerning the nature of the sea-bottom in the cold zone around the south pole. Between the years 1839 and 1843, Sir James Clark Ross executed his famous antarctic expedition, in the course of which he penetrated, at two widely-distant points of the antarctic zone, into the high latitudes of the shores of Victoria Land and of Graham's Land, and reached the parallel of 80° south. Sir James Ross was himself a naturalist of no mean acquirements, and Dr. Hooker, the present President of the Royal Society, accompanied him as naturalist to the expedition, so that the observations upon the fauna and flora of the antarctic regions made during this cruise were sure to have a peculiar value and importance, even had not the attention of the voyagers been particularly directed to the importance of noting the occurrence of the minutest forms of animal and vegetable life in the ocean.

Among the scientific instructions for the voyage drawn up by a committee of the Royal Society, however, there is a remarkable letter from Von Humboldt to Lord Minto, then First Lord of the Admiralty, in which, among other things, he dwells upon the significance of the researches into the microscopic composition of rocks, and the discovery of the great share which microscopic organisms take in the formation of the crust of the earth at the present day, made by Ehrenberg

[1] "Ueber neue Auschauungen des kleinsten nördlichen Polarlebens," *Monatsberichte der Königlichen Akademie*, Berlin, 1853.

in the years 1836–'39. Ehrenberg, in fact, had shown that the extensive beds of "rotten-stone" or "Tripoli" which occur in various parts of the world, and notably at Bilin in Bohemia, consisted of accumulations of the silicious cases and skeletons, *Diatomaceæ*, sponges, and *Radiolaria;* he had proved that similar deposits were being formed by *Diatomaceæ* in the pools of the Thiergarten, in Berlin and elsewhere, and had pointed out that, if it were commercially worth while, rotten-stone might be manufactured by a process of diatom-culture. Observations, conducted at Cuxhaenv in 1839, had revealed the existence, at the surface of the waters of the Baltic, of living diatoms and *Radiolaria* of the same species as those which, in a fossil state, constitute extensive rocks of Tertiary age at Caltanisetta, Zante, and Oran, on the shores of the Mediterranean.

Moreover, in the fresh-water rotten-stone beds of Bilin, Ehrenberg had traced out the metamorphosis, effected apparently by the action of percolating water, of the primitively loose and friable deposit of organized particles, in which the silex exists in the hydrated or soluble condition. The silex, in fact, undergoes solution and slow redeposition, until, in ultimate result, the excessively fine-grained sand, each particle of which is a skeleton, becomes converted into a dense opaline stone, with only here and there an indication of an organism.

From the consideration of these facts, Ehrenberg, as early as the year 1839, had arrived at the conclusion that rocks, altogether similar to those which constitute a large part of the crust of the earth, must be forming, at the present day, at the bottom of the sea; and he threw out the suggestion that even where no traces of organic structure is to be found in the older rocks, it may have been lost by metamorphosis.[1]

The results of the antarctic exploration, as stated by Dr. Hooker in the "Botany of the Antarctic Voyage," and in a paper which he read before the British Association in 1847, are of the greatest importance in connection with these views, and they are so clearly stated in the former work, which is somewhat inaccessible, that I make no apology for quoting them at length:

"The waters and the ice of the South Polar Ocean were alike found to abound with microscopic vegetables belonging to the order *Diatomaceæ*. Though much too small to be discernible by the naked eye, they occurred in such countless myriads as to stain the berg and the pack-ice wherever they were washed by the swell of the sea; and, when inclosed in the congealing surface of the water, they imparted to the brash and pancake-ice a pale ochreous color. In the open ocean, northward of the frozen zone, this order, though no doubt al-

[1] "Ueber die noch jetzt zahlreich lebenden Thierarten der Kreidebildung und den Organismus der Polythalamien," *Abhandlungen der Königlichen Akademie der Wissenschaften*, 1839. Berlin, 1841. I am afraid that this remarkable paper has been somewhat overlooked in the recent discussions of the relation of ancient rocks to modern deposits.

most universally present, generally eludes the search of the naturalist; except when its species are congregated among that mucous scum which is sometimes seen floating on the waves, and of whose real nature we are ignorant; or when the colored contents of the marine animals who feed on these algæ are examined. To the south, however, of the belt of ice which encircles the globe, between the parallels of 50° and 70° south, and in the waters comprised between that belt and the highest latitude ever attained by man, this vegetation is very conspicuous, from the contrast between its color and the white snow and ice in which it is embedded. Insomuch, that in the eightieth degree, all the surface-ice carried along by the currents, the sides of every berg, and the base of the great Victoria Barrier itself, within reach of the swell, were tinged brown, as if the polar waters were charged with oxide of iron.

"As the majority of these plants consist of very simple vegetable cells, inclosed in the indestructible silex (as other algæ are in carbonate of lime), it is obvious that the death and decomposition of such multitudes must form sedimentary deposits, proportionate in their extent to the length and exposure of the coast against which they are washed, in thickness to the power of such agents as the winds, currents, and sea, which sweep them more energetically to certain positions, and in purity, to the depth of the water and nature of the bottom. Hence we detected their remains along every ice-bound shore, in the depths of the adjacent ocean, between 80 and 400 fathoms. Off Victoria Barrier (a perpendicular wall of ice between 100 and 200 feet above the level of the sea) the bottom of the ocean was covered with a stratum of pure white or green mud, composed principally of the silicious shells of the *Diatomaceæ*. These, on being put into water, rendered it cloudy like milk, and took many hours to subside. In the very deep water off Victoria and Graham's Land, this mud was particularly pure and fine; but toward the shallow shores there existed a greater or less admixture of disintegrated rock and sand; so that the organic compounds of the bottom frequently bore but a small proportion to the inorganic. . . ."

"The universal existence of such an invisible vegetation as that of the Antarctic Ocean is a truly wonderful fact, and the more from its not being accompanied by plants of a high order. During the years we spent there, I had been accustomed to regard the phenomena of life as differing totally from what obtains throughout all other latitudes, for every thing living appeared to be of animal origin. The ocean swarmed with *Mollusca*, and particularly entomostratous *Crustacea*, small whales, and porpoises; the sea abounded with penguins and seals, and the air with birds; the animal kingdom was ever present, the larger creatures preying on the smaller, and these again on smaller still; all seemed carnivorous. The herviborous were not recognized, because feeding on a microscopic herbage, of whose true nature I had formed an erroneous impression. It is, therefore, with no little satisfaction that I now class the *Diatomaceæ* with plants, probably maintaining in the South Polar Ocean that balance between the vegetable and animal kingdoms which prevails over the surface of our globe. Nor is the sustenance and nutrition of the animal kingdom the only function these minute productions may perform; they may also be the purifiers of the vitiated atmosphere, and thus execute in the antarctic latitudes the office of our trees and grass-turf in the temperate regions, and the broad leaves of the palm, etc., in the tropics. . . ."

With respect to the distribution of the *Diatomaceæ*, Dr. Hooker remarks:

"There is probably no latitude, between that of Spitzbergen and Victoria Land, where some of the species of either country do not exist: Iceland, Britain, the Mediterranean Sea, North and South America, and the South-Sea Islands, all possess antarctic *Diatomaceæ.* The silicious coats of species only known living in the waters of the South Polar Ocean, have, during past ages, contributed to the formation of rocks; and thus they outlive several successive creations of organized beings. The phronolite stones of the Rhine, and the Tripoli stone, contain species identical with what are now contributing to form a sedimentary deposit (and, perhaps, at some future period, a bed of rock) extending in one continuous stratum for 400 measured miles. I allude to the shores of the Victoria Barrier, along whose coast the soundings examined were invariably charged with diatomaceous remains, constituting a bank which stretches 200 miles north from the base of Victoria Barrier, while the average depth of water above it is 300 fathoms, or 1,800 feet. Again, some of the antarctic species have been detected floating in the atmosphere which overhangs the wide ocean between Africa and America. The knowledge of this marvelous fact we owe to Mr. Darwin, who, when he was at sea off the Cape de Verd Islands, collected an impalpable powder which fell on Captain Fitzroy's ship. He transmitted this dust to Ehrenberg, who ascertained it to consist of the silicious coats, chiefly of American *Diatomaceæ*, which were being wafted through the upper region of the air, when some meteorological phenomena checked them in their course and deposited them on the ship and surface of the ocean.

"The existence of the remains of many species of this order (and among them some antarctic ones) in the volcanic ashes, pumice, and scoriæ of active and extinct volcanoes (those of the Mediterranean Sea and Ascension Island, for instance), is a fact bearing immediately upon the present subject. Mount Erebus, a volcano 12,400 feet high, of the first class in dimensions and energetic action, rises at once from the ocean in the seventy-eighth degree of south latitude, and abreast of the *Diatomaceæ* bank, which reposes in part on its base. Hence it may not appear preposterous to conclude that, as Vesuvius receives the waters of the Mediterranean, with its fish, to eject them by its crater, so the subterranean and subaqueous forces which maintain Mount Erebus in activity may occasionally receive organic matter from the bank, and disgorge it, together with those volcanic products, ashes and pumice.

"Along the shores of Graham's Land and the South Shetland Islands we have a parallel combination of igneous and aqueous action, accompanied with an equally copious supply of *Diatomaceæ.* In the Gulf of Erebus and Terror, fifteen degrees north of Victoria Land, and placed on the opposite side of the globe, the soundings were of a similar nature with those of the Victoria Land and Barrier, and the sea and ice as full of *Diatomaceæ.* This was not only proved by the deep-sea lead, but by the examination of bergs which, once stranded, had floated off and become reversed, exposing an accumulation of white friable mud frozen to their bases, which abounded with these vegetable remains."

The Challenger has explored the antarctic seas in a region intermediate between those examined by Sir James Ross's expedition; and the observations made by Dr. Wyville Thomson and his colleagues in every respect confirm those of Dr. Hooker:

"On the 11th of February, latitude 60° 52′ south, longitude 80° 20′ east, and March 3d, latitude 53° 55′ south, longitude 108° 35′ east, the sounding instrument came up filled with a very fine cream-colored paste, which scarcely effer-

vesced with acid, and dried into a very light, impalpable, white powder. This, when examined under the microscope, was found to consist almost entirely of the frustules of diatoms, some of them wonderfully perfect in all the details of their ornament, and many of them broken up. The species of diatoms entering into this deposit have not yet been worked up, but they appear to be referable chiefly to the genera *Fragillaria*, *Coscinodiscus*, *Chætoceros*, *Asteromphalus*, and *Dictyocha*, with fragments of the separated rods of a singular silicious organism, with which we were unacquainted, and which made up a large proportion of the finer matter of this deposit. Mixed with the diatoms there were a few small *Globigerinæ*, some of the tests and spicules of radiolarians, and some sand-particles; but these foreign bodies were in too small proportion to affect the formation as consisting practically of diatoms alone. On the 4th of February, in latitude 52° 29′ south, longitude 71° 36′ east, a little to the north of the Heard Islands, the tow-net, dragging a few fathoms below the surface, came up nearly filled with a pale-yellow gelatinous mass. This was found to consist entirely of diatoms of the same species as those found at the bottom. By far the most abundant was the little bundle of silicious rods, fastened together loosely at one end, separating from one another at the other end, and the whole bundle loosely twisted into a spindle. The rods are hollow, and contain the characteristic endochrome of the *Diatomaceæ*. Like the *Globigerina* ooze, then, which it succeeds to the southward in a band apparently of no great width, the materials of this silicious deposit are derived entirely from the surface and intermediate depths. It is somewhat singular that diatoms did not appear to be in such large numbers on the surface over the diatom-ooze as they were a little farther north. This may perhaps be accounted for by our not having struck their belt of depth with the tow-net; or it is possible that, when we found it on the 11th of February, the bottom deposit was really shifted a little to the south by the warm current, the excessively fine flocculent *débris* of the diatoms taking a certain time to sink. The belt of diatom-ooze is certainly a little farther to the southward in longitude 83° east, in the path of the reflux of the Agulhas current, than in longitude 108° east.

"All along the edge of the ice-pack—everywhere, in fact, to the south of the two stations—on the 11th of February, on our southward voyage, and on the 3d of March, on our return, we brought up fine sand and grayish mud, with small pebbles of quartz and feldspar, and small fragments of mica-slate, chlorite-slate, clay-slate, gneiss, and granite. This deposit, I have no doubt, was derived from the surface like the others, but in this case by the melting of icebergs and the precipitation of foreign matter contained in the ice.

"We never saw any trace of gravel or sand, or any material necessarily derived from land, on an iceberg. Several showed vertical or irregular fissures filled with discolored ice or snow; but, when looked at closely, the discoloration proved usually to be very slight, and the effect at a distance was usually due to the foreign material filling the fissure reflecting light less perfectly than the general surface of the berg. I conceive that the upper surface of one of these great tabular southern icebergs, including by far the greater part of its bulk, and culminating in the portion exposed above the surface of the sea, was formed by the piling up of successive layers of snow during the period, amounting perhaps to several centuries, during which the ice-cap was slowly forcing itself over the low land and out to sea over a long extent of gentle slope, until it reached a depth considerably above 200 fathoms, when the lower specific weight of the ice caused an upward strain which at length overcame the cohesion of the mass,

and portions were rent off and floated away. If this be the true history of the formation of these icebergs, the absence of all land *débris* in the portion exposed above the surface of the sea is readily understood. If any such exist, it must be confined to the lower part of the berg, to that part which has at one time or other moved on the floor of the ice-cap.

"The icebergs, when they are first dispersed, float in from 200 to 250 fathoms. When, therefore, they have been drifted to latitudes of 65° or 64° south, the bottom of the berg just reaches the layer at which the temperature of the water is distinctly rising, and it is rapidly melted, and the mud and the pebbles with which it is more or less charged are precipitated. That this precipitation takes place all over the area where the icebergs are breaking up, constantly, and to a considerable extent, is evident from the fact of the soundings being entirely composed of such deposits; for the diatoms, *Globigerinæ*, and radiolarians, are present on the surface in large numbers; and unless the deposit from the ice were abundant it would soon be covered and masked by a layer of the exuvia of surface organisms."

The observations which have been detailed leave no doubt that the antarctic sea-bottom, from a little to the south of the fiftieth parallel, as far as 80° south, is being covered by a fine deposit of silicious mud, more or less mixed, in some parts, with the ice-borne *débris* of polar lands and with the ejections of volcanoes. The silicious particles which constitute this mud are derived, in part, from the diatomaceous plants and radiolarian animals which throng the surface, and, in part, from the spicula of sponges which live at the bottom. The evidence respecting the corresponding arctic area is less complete, but it is sufficient to justify the conclusion that an essentially similar silicious cap is being formed around the northern pole.

There is no doubt that the constituent particles of this mud may agglomerate into a dense rock, such as that formed at Oran, on the shores of the Mediterranean, which is made up of similar materials. Moreover, in the case of fresh-water deposits of this kind, it is certain that the action of percolating water may convert the originally soft and friable, fine-grained sandstone into a dense semi-transparent opaline stone, the silicious organized skeletons being dissolved, and the silex redeposited in an amorphous state. Whether such a metamorphosis as this occurs in submarine deposits, as well as in those formed in fresh water, does not appear; but there seems no reason to doubt that it may. And hence it may not be hazardous to conclude that very ordinary metamorphic agencies may convert these polar caps into a form of quartzite.

In the great intermediate zone, occupying some 110° of latitude, which separates the circumpolar arctic and antarctic areas of silicious deposit, the diatoms and *Radiolaria* of the surface-water and the sponges of the bottom do not die out, and, so far as some forms are concerned, do not even appear to diminish in total number; though, on a rough estimate, it would appear that the proportion of *Radiola-*

*ria* to diatoms is much greater than in the colder seas. Nevertheless the composition of the deep-sea mud of this intermediate zone is entirely different from that of the circumpolar regions.

The first exact information respecting the nature of this mud at depths greater than 1,000 fathoms was given by Ehrenberg, in the account which he published in the "Monatsberichte" of the Berlin Academy for the year 1853, of the soundings obtained by Lieutenant Berryman, of the United States Navy, in the North Atlantic, between Newfoundland and the Azores.

Observations which confirm those of Ehrenberg in all essential respects have been made by Prof. Bailey, myself, Dr. Wallich, Dr. Carpenter, and Prof. Wyville Thomson, in their earlier cruises; and the continuation of the *Globigerina* ooze over the South Pacific has been proved by the recent work of the Challenger, by which it is also shown, for the first time, that, in passing from the equator to high southern latitudes, the number and variety of the *Foraminifera* diminish, and even the *Globigerinæ* become dwarfed. And this result, it will be observed, is in entire accordance with the fact already mentioned that, in the sea of Kamtchatka, the deep sea mud was found by Bailey to contain no calcareous organisms.

Thus, in the whole of the "intermediate zone," the silicious deposit which is being formed there, as elsewhere, by the accumulation of sponge-spicula, *Radiolaria*, and diatoms, is obscured and overpowered by the immensely greater amount of calcareous sediment, which arises from the aggregation of the skeletons of dead *Foraminifera*. The similarity of the deposit, thus composed of a large percentage of carbonate of lime, and a small percentage of silex, to chalk, regarded merely as a kind of rock, which was first pointed out by Ehrenberg,[1] is now admitted on all hands; nor can it be resonably doubted that ordinary metamorphic agencies are competent to convert the "modern chalk" into hard limestone, or even into crystalline marble.

Ehrenberg appears to have taken it for granted that the *Globi-*

[1] The following passages, in Ehrenberg's memoir on "The Organisms in the Chalk which are still living" (1839), are conclusive:

"7. The dawning period of the existing living organic creation, if such a period is distinguishable (which is doubtful), can only be supposed to have existed on the other side of, and below, the chalk formation; and thus, either the chalk, with its wide-spread and thick beds, must enter into the series of newer formations, or some of the accepted four great geological periods—the quaternary, tertiary, and secondary formations—contain organisms which still live. It is more probable, in the proportion of three to one, that the transition or primary period is not different, but that it is only more difficult to examine and understand, by reason of the gradual and prolonged chemical decomposition and metamorphosis of many of its organic constituents."

"10. By the mass-forming *Infusoria* and *Polythalamia*, secondary are not distinguishable from tertiary formations; and, from what has been said, it is possible that, at this very day, rock-masses are forming in the sea, and being raised by volcanic agencies, the constitution of which, on the whole, is altogether similar to that of the chalk. The chalk remains distinguishable by its organic remains as a formation, but not as a kind of rock."

*gerinæ* and other *Foraminifera* which are found in the deep-sea mud, live at the great depths in which their remains are found; and he supports this opinion by producing evidence that the soft parts of these organisms are preserved, and may be demonstrated by removing the calcareous matter with dilute acids. In 1857 the evidence for and against this conclusion appeared to me to be insufficient to warrant a positive conclusion one way or the other, and I expressed myself, in my report to the Admiralty on Captain Dayman's soundings, in the following terms:

"When we consider the immense area over which this deposit is spread, the depth at which its formation is going on, and its similarity to chalk, and still more to the marls of Caltanisetta, the question, 'Whence are these organisms derived?' becomes one of high scientific interest.

"Three answers have suggested themselves:

"In accordance with the prevalent view of the limitation of life to comparatively small depths, it is imagined either: 1. That these organisms have drifted into their present position from shallower waters; or 2. That they habitually live at the surface of the ocean, and only fall down into their present position.

"1. I conceive that the first supposition is negatived by the extremely marked zoological peculiarity of the deep-sea fauna.

"Had the *Globigerinæ* been drifted into their present position from shallow water, we should find a very large proportion of the characteristic inhabitants of shallow water mixed with them, and this would the more certainly be the case, as the large *Globigerinæ*, so abundant in the deep-sea soundings, are, in proportion to their size, more massive and solid than almost any other *Foraminifera*. But the fact is, that the proportion of other *Foraminifera* is exceedingly small, nor have I found as yet, in the deep-sea deposits, any such matters as fragments of molluscous shells, of *Echini*, etc., which abound in shallow waters, and are quite as likely to be drifted as the heavy *Globigerinæ*. Again, the relative proportions of young and fully-formed *Globigerinæ* seem inconsistent with the notion that they have traveled far. And it seems difficult to imagine why, had the deposit been accumulated in this way, *Coscinodisci* should so almost entirely represent the *Diatomaceæ*.

"2. The second hypothesis is far more feasible, and is strongly supported by the fact that many *Polycistineæ* (*Radiolaria*) and *Coscinodisci* are well known to live at the surface of the ocean. Mr. Macdonald, Assistant Surgeon of H. M. S. Herald, now in the Southwestern Pacific, has lately sent home some very valuable observations on living forms of this kind, met with in the stomachs of oceanic mollusks, and therefore certainly inhabitants of the superficial layer of the ocean. But it is a singular circumstance that only one of the forms figured by Mr. Macdonald is at all like a *Globigerina*, and there are some peculiarities about even this which make me greatly doubt its affinity with that genus. The form, indeed, is not unlike that of a *Globigerina*, but it is provided with long radiating processes, of which I have never seen any trace in *Globigerina*. Did they exist, they might explain what otherwise is a great objection to this view, viz., how is it conceivable that the heavy *Globigerina* should maintain itself at the surface of the water?

"If the organic bodies in the deep-sea soundings have neither been drifted, nor have fallen from above, there remains but one alternative—they must have lived and died as they are.

"Important objections, however, at once suggest themselves to this view. How can animal life be conceived to exist under such conditions of light, temperature, pressure, and aëration as must obtain at these vast depths?

"To this one can only reply that we know for a certainty that even very highly-organized animals do continue to live at a depth of 300 and 400 fathoms, inasmuch as they have been dredged up thence; and that the difference in the amount of light and heat at 400 and 2,000 fathoms is probably, so to speak, very far less than the difference in complexity of organization between these animals and the humbler *Protozoa* and *Protophyta* of the deep-sea soundings.

"I confess, though as yet far from regarding it proved that the *Globigerinæ* live at these depths, the balance of probabilities seems to me to incline in that direction. And there is one circumstance which weighs strongly in my mind. It may be taken as a law that any genus of animals that is found far back in time is capable of living under a great variety of circumstances as regards light, temperature, and pressure. Now, the genus *Globigerina* is abundantly represented in the Cretaceous epoch, and perhaps earlier.

"I abstain, however, at present from drawing any positive conclusions, preferring rather to await the result of more extended observations."[1]

Dr. Wallich, Prof. Wyville Thomson, and Dr. Carpenter, concluded that the *Globigerinæ* live at the bottom. Dr. Wallich writes in 1862: "By sinking very fine gauze-nets to considerable depths, I have repeatedly satisfied myself that *Globigerina* does not occur in the superficial strata of the ocean."[2] Moreover, having obtained certain living star-fish from a depth of 1,260 fathoms, and found their stomachs full of "fresh-looking *Globigerinæ*" and their *débris*, he adduces this fact in support of his belief that the *Globigerinæ* live at the bottom.

On the other hand, Müller, Häckel, Major Owen, Mr. Gwyn Jeffries, and other observers, found that *Globigerinæ*, with the allied genera *Orbulina* and *Pulvinulina*, sometimes occur abundantly at the surface of the sea, the shells of these pelagic forms being not unfrequently provided with the long spines noticed by Macdonald; and in 1865 and 1866 Major Owen more especially insisted on the importance of this fact. The recent work of the Challenger fully confirms Major Owen's statement. In the paper recently published in the proceedings of the Royal Society,[3] from which a quotation has already been made, Prof. Wyville Thomson says:

"I had formed and expressed a very strong opinion on the matter. It seemed to me that the evidence was conclusive that the *Foraminifera* which formed the *Globigerina* ooze lived on the bottom, and that the occurrence of individuals on the surface was accidental and exceptional; but, after going into the thing carefully, and considering the mass of evidence which has been accumulated by Mr. Murray, I now admit that I was in error; and I agree with him that it may be

[1] Appendix to "Report on Deep-Sea Soundings in the Atlantic Ocean," by Lieutenant-Commander Joseph Dayman, 1857.

[2] The "North Atlantic Sea-Bed," p. 137.

[3] "Preliminary Notes on the Nature of the Sea-Bottom procured by the Soundings of H. M. S. Challenger during her Cruise in the Southern Seas in the Early Part of the Year 1874."—(Proceedings of the Royal Society, November 26, 1874.)

taken as proved that all the materials of such deposits, with the exception, of course, of the remains of animals which we now know to live at the bottom of all depths, which occur in the deposit as foreign bodies, are derived from the surface.

"Mr. Murray has combined with a careful examination of the soundings a constant use of the tow-net, usually at the surface, but also at depths of from 10 to 100 fathoms, and he finds the closest relation to exist between the surface fauna of any particular locality and the deposit which is taking place at the bottom. In all seas, from the equator to the polar ice, the tow-net contains *Globigerinæ*. They are more abundant and of a larger size in warmer seas; several varieties, attaining a large size, and presenting marked varietal characters, are found in the intertropical area of the Atlantic. In the latitude of Kerguelen they are less numerous and smaller, while farther south they are still more dwarfed, and only one variety, the typical *Globigerina bulloides*, is represented. The living *Globigerinæ* from the tow-net are singularly different in appearance from the dead shells we find at the bottom. The shell is clear and transparent, and each of the pores which penetrate it is surrounded by a raised crest, the crest round adjacent pores coalescing into a roughly hexagonal net-work, so that the pores appear to lie at the bottom of an hexagonal pit. At each angle of this hexagon the crest gives off a delicate, flexible, calcareous spine, which is sometimes four or five times the diameter of the shell in length. The spines radiate symmetrically from the direction of the centre of each chamber of the shell, and the sheaves of long transparent needles crossing one another in different directions have a very beautiful effect. The smaller inner chambers of the shell are entirely filled with an orange-yellow granular sarcode; and the large terminal chamber usually contains only a small irregular mass, or two or three small masses run together, of the same yellow sarcode stuck against one side, the remainder of the chamber being empty. No definite arrangement and no approach to structure was observed in the sarcode, and no differentiation, with the exception of round bright-yellow oil-globules, very much like those found in some of the radiolarians which are scattered, apparently irregularly, in the sarcode. We never have been able to detect, in any of the large number of *Globigerinæ* which we have examined, the least trace of pseudopodia, or any extension, in any form, of the sarcode beyond the shell. . . .

"In specimens taken with the tow-net the spines are very usually absent; but that is probably on account of their extreme tenuity; they are broken off by the slightest touch. In fresh examples from the surface, the dots indicating the origin of the lost spines may almost always be made out with a high power. There are never spines on the *Globigerinæ* from the bottom, even in the shallowest water."

There can now be no doubt, therefore, that the *Globigerinæ* live at the top of the sea; but the question may still be raised whether they do not also live at the bottom. In favor of this view, it has been urged that the shells of the *Globigerinæ* of the surface never possess such thick walls as those which are found at the bottom, but I confess that I doubt the accuracy of this statement. Again, the occurrence of minute *Globigerinæ* in all stages of development, at the greatest depths, is brought forward as evidence that they live *in situ*. But, considering the extent to which the surface-organisms are devoured, without discrimination of young and old, by *Salpæ* and the like, it is not wonderful that the shells of all ages should be among the *rejecta-*

*menta.* Nor can the presence of the soft parts of the body in the shells which form the *Globigerina* ooze, and the fact, if it be one, that animals living at the bottom use them as food, be considered as conclusive evidence that the *Globigerinæ* live at the bottom. Such as die at the surface, and even many of those which are swallowed up by other animals, may retain much of their protoplasmic matter when they reach the depths at which the temperature sinks to 34° or 32° Fahr., where decomposition must become exceedingly slow.

Another consideration appears to me to be in favor of the view that the *Globigerinæ* and their allies are essentially surface-animals. This is the fact brought out by the Challenger's work, that they have a southern limit of distribution, which can hardly depend upon any thing but the temperature of the surface-water. And it is to be remarked that this southern limit occurs at a lower latitude in the antarctic seas than it does in the North Atlantic. According to Dr. Wallich ("The North-Atlantic Sea-Bed," p. 157) *Globigerina* is the prevailing form in the deposits between the Farœ Islands and Iceland, and between Iceland and East Greenland—or, in other words, in a region of the sea-bottom which lies altogether north of the parallel of 60° north; while in the southern seas the *Globigerinæ* become dwarfed and almost disappear between 50° and 55° south. On the other hand, in the sea of Kamtchatka, the *Globigerinæ* have vanished in 56° north, so that the persistence of the *Globigerina* ooze in high latitudes, in the North Atlantic, would seem to depend on the northward curve of the isothermals peculiar to this region; and it is difficult to understand how the formation of *Globigerina* ooze can be affected by this climatal peculiarity unless it be effected by surface animals.

Whatever may be the mode of life of the *Foraminifera*, to which the calcareous element of the deep-sea "chalk" owes its existence, the fact that it is the chief and most widely-spread material of the sea-bottom in the intermediate zone, throughout both the Atlantic and Pacific Oceans, and the Indian Ocean, at depths from a few hundred to over 2,000 fathoms, is established. But it is not the only extensive deposit which is now taking place. In 1853 Count Pourtalès, an officer of the United States Coast Survey, which has done so much for scientific hydrography, observed that the mud forming the sea-bottom at depths of 150 fathoms, in 31° 32′ north, and 79° 35′ west, off the coast of Florida, was "a mixture, in about equal proportions, of *Globigerinæ* and black sand, probably green sand, as it makes a green mark when crushed on paper." Prof. Bailey, examining these grains microscopically, found that they were casts of the interior cavities of *Foraminifera*, consisting of a mineral known as *Glauconite*, which is a silicate of iron and alumina. In these casts the minutest cavities and finest tubes in the *Foraminifera* were sometimes reproduced in solid counterparts of the glassy mineral, while the calcareous original had been entirely dissolved away.

Contemporaneously with these observations, the indefatigable Ehrenberg had discovered that the "greensands" of the geologist were largely made up of casts of a similar character, and proved the existence of *Foraminifera* at a very ancient geological epoch, by discovering such casts in a greensand of Lower Silurian age, which occurs near St. Petersburg.

Subsequently Messrs. Parker and Jones discovered similar casts in process of formation, the original shell not having disappeared, in specimens of the sea-bottom of the Australian seas, brought home by the late Prof. Jukes. And the Challenger has observed a deposit of a similar character in the course of the Agulhas current, near the Cape of Good Hope, and in some other localities not yet defined.

It would appear that this infiltration of *Foraminifera* shells with *Glauconite* does not take place at great depths, but rather in what may be termed a sublittoral region, ranging from 100 to 300 fathoms. It cannot be ascribed to any local cause, for it takes place, not only over large areas in the Gulf of Mexico and the coast of Florida, but in the South Atlantic and in the Pacific. But what are the conditions which determine its occurrence, and whence the silex, the iron, and the alumina (with perhaps potash and some other ingredients in small quantity) of which the *Glauconite* is composed, proceed, are points on which no light has yet been thrown. For the present we must be content with the fact that, in certain areas of the "intermediate zone," greensand is replacing and representing the primitive calcareo-silicious ooze.

The investigation of the deposits which are now being formed in the basin of the Mediterranean by the late Prof. Edward Forbes, by Prof. Williamson, and more recently by Dr. Carpenter, and a comparison of the results thus obtained with what is known of the surface fauna, have brought to light the remarkable fact that, while the surface and the shallows abound with *Foraminifera* and other calcareous-shelled organisms, the indications of life become scanty at depths beyond 500 or 600 fathoms, while almost all traces of it disappear at greater depths, and at 1,000 to 2,000 fathoms the bottom is covered with a fine clay.

Dr. Carpenter has discussed the significance of this remarkable fact, and he is disposed to attribute the absence of life at great depths partly to the absence of any circulation of the water of the Mediterranean at such depths, and partly to the exhaustion of the oxygen of the water by the organic matter contained in the fine clay, which he conceives to be formed by the finest particles of the mud brought down by the rivers which flow into the Mediterranean.

However this may be, the explanation thus offered of the presence of the fine mud, and of the absence of organisms which ordinarily live at the bottom, does not account for the absence of the skeletons

of the organisms which undoubtedly abound at the surface of the Mediterranean; and it would seem to have no application to the remarkable fact discovered by the Challenger, that in the open Atlantic and Pacific Oceans, in the midst of the great intermediate zone, and thousands of miles away from the embouchure of any river, the sea-bottom, at depths approaching to and beyond 3,000 fathoms, no longer consists of *Globigerina* ooze, but an excessively fine red clay.

Prof. Thomson gives the following account of this capital discovery:

"According to our present experience, the deposit of *Globigerina* ooze is limited to water of a certain depth, the extreme limit of the pure characteristic formation being placed at a depth of somewhere about 2,250 fathoms. Crossing from these shallower regions occupied by the ooze into deeper surroundings, we find universally that the calcareous formation gradually passes into, and is finally replaced by, an extremely fine pure clay, which occupies, speaking generally, all depths below 2,500 fathoms, and consists almost entirely of a silicate of the red oxide of iron and alumina. The transition is very slow, and extends over several hundred fathoms of increasing depth; the shells gradually lose their sharpness of outline, and assume a kind of 'rotten' look and a brownish color, and become more and more mixed with a fine amorphous red-brown powder, which increases steadily in proportion, until the lime has almost entirely disappeared. The brown matter is in the finest possible state of subdivision; so fine that, when, after sifting it to separate any organisms it might contain, we put it into jars to settle, it remained for days in suspension, giving the water very much the appearance and color of chocolate.

"In indicating the nature of the bottom on the charts, we came, from experience and without any theoretical considerations, to use three terms for soundings in deep water. Two of these, *Globigerina* ooze and red clay, were very definite, and indicated strongly-marked formations, with apparently but few characters in common; but we frequently got soundings which we could not exactly call '*Globigerina* ooze' or 'red clay,' and, before we were fully aware of the nature of these, we were in the habit of indicating them as 'gray ooze' (gr. oz.). We now recognize the 'gray ooze' as an intermediate stage between the *Globigerina* ooze and the red clay; we find that on one side, as it were, of an ideal line, the red clay contains more and more of the material of the calcareous ooze, while on the other the ooze is mixed with an increasing proportion of 'red clay.'

"Although we have met with the same phenomenon so frequently that we were at length able to predict the nature of the bottom from the depth of the surroundings with absolute certainty for the Atlantic and the Southern Sea, we had, perhaps, the best opportunity of observing it in our first section across the Atlantic, between Teneriffe and St. Thomas. The first four stations on this section, at depths from 1,525 to 2,220 fathoms, show *Globigerina* ooze. From the last of these, which is about 300 miles from Teneriffe, the depth gradually increases to 2,740 fathoms at 500, and 2,950 fathoms at 750 miles from Teneriffe. The bottom in these two soundings might have been called 'gray ooze,' for, although its nature has altered entirely from the *Globigerina* ooze, the red clay into which it is rapidly passing still contains a considerable admixture of carbonate of lime.

"The depth goes on increasing to a distance of 1,150 miles from Teneriffe,

when it reaches 3,150 fathoms; there the clay is pure and smooth, and contains scarcely a trace of lime. From this great depth the bottom gradually rises, and, with decreasing depth, the gray color and the calcareous composition of the ooze return. Three soundings, in 2,050, 1,900, and 1,950 fathoms on the 'Dolphin rise,' gave highly-characteristic examples of the *Globigerina* formation. Passing from the middle plateau of the Atlantic into the western trough, with depths a little over 3,000 fathoms, the red clay returned in all its purity; and our last sounding, in 1,420 fathoms, before reaching Sombrero, restored the *Globigerina* ooze with its peculiar associated fauna.

"This section shows also the wide extension and the vast geological importance of the red-clay formation. The total distance from Teneriffe to Sombrero is about 2,700 miles. Proceeding from east to west we have—

| | | | |
|---|---|---|---|
| About | 80 | miles of | volcanic mud and sand, |
| " | 350 | " | *Globigerina* ooze, |
| " | 1,050 | " | red clay, |
| " | 330 | " | *Globigerina* ooze, |
| " | 850 | " | red clay, |
| " | 40 | " | *Globigerina* ooze; |

giving a total of 1,900 miles of red clay to 720 miles of *Globigerina* ooze.

"The nature and origin of this vast deposit of clay is a question of the very greatest interest; and although I think there can be no doubt that it is in the main solved, yet some matters of detail are still involved in difficulty. My first impression was that it might be the most minutely-divided material, the ultimate sediment produced by the disintegration of the land, by rivers and by the action of the sea on exposed coasts, and held in suspension and distributed by ocean-currents, and only making itself manifest in places unoccupied by the *Globigerina* ooze. Several circumstances seemed, however, to negative this mode of origin. The formation seemed too uniform; wherever we met with it, it had the same character, and it only varied in composition in containing less or more carbonate of lime.

"Again, we were gradually becoming more and more convinced that all the important elements of the *Globigerina* ooze lived on the surface, and it seemed evident that, so long as the condition on the surface remained the same, no alteration of contour at the bottom could possibly prevent its accumulation; and the surface conditions in the mid-Atlantic were very uniform, a moderate current of a very equal temperature passing continuously over elevations and depressions, and everywhere yielding to the tow-net the ooze-forming *Foraminifera* in the same proportion. The mid-Atlantic swarms with pelagic *Mollusca*, and, in moderate depths, the shells of these are constantly mixed with the *Globigerina* ooze, sometimes in number sufficient to make up a considerable portion of its bulk. It is clear that these shells must fall in equal numbers upon the red-clay, but scarcely a trace of one of them is ever brought up by the dredge on the red-clay area. It might be possible to explain the absence of shell-secreting animals living on the bottom, on the supposition that the nature of the deposit was injurious to them; but then the idea of a current sufficiently strong to sweep them away is negatived by the extreme fineness of the sediment which is being laid down; the absence of surface-shells appears to be intelligible only on the supposition that they are in some way removed.

"We conclude, therefore, that the 'red clay' is not an additional substance introduced from without, and occupying certain depressed regions on account of some law regulating its deposition, but that it is produced by the removal, by

some means or other, over these areas, of the carbonate of lime, which forms probably about 98 per cent. of the material of the *Globigerina* ooze. We can trace, indeed, every successive stage in the removal of the carbonate of lime in descending the slope of the ridge or plateau where the *Globigerina* ooze is forming, to the region of the clay. We find, first, that the shells of pteropods and other surface *Mollusca*, which are constantly falling on the bottom, are absent, or, if a few remain, they are brittle and yellow, and evidently decaying rapidly. These shells of *Mollusca* decompose more easily and disappear sooner than the smaller, and apparently more delicate, shells of rhizopods. The smaller *Foraminifera* now give way, and are found in lessening proportion to the larger; the coccoliths first lose their thin outer border and then disappear; and the clubs of the rhabdoliths get worn out of shape, and are last seen, under a high power, as infinitely minute cylinders scattered over the field. The larger *Foraminifera* are attacked, and instead of being vividly white and delicately sculptured, they become brown and worn, and finally they break up, each according to its fashion; the chamber-walls of *Globigerina* fall into wedge-shaped pieces, which quickly disappear, and a thick rough crust breaks away from the surface of *Orbulina*, leaving a thin inner sphere, at first beautifully transparent, but soon becoming opaque and crumbling away.

"In the mean time the proportion of the amorphous 'red clay' to the calcareous elements of all kinds increases, until the latter disappear, with the exception of a few scattered shells of the larger *Foraminifera*, which are still found even in the most characteristic samples of the 'red clay.'

"There seems to be no room left for doubt that the red clay is essentially the insoluble residue, the *ash*, as it were, of the calcareous organisms which form the *Globigerina* ooze, after the calcareous matter has been by some means removed. An ordinary mixture of calcareous *Foraminifera* with the shells of pteropods, forming a fair sample of *Globigerina* ooze from near St. Thomas, was carefully washed, and subjected by Mr. Buchanan to the action of weak acid; and he found that there remained, after the carbonate of lime had been removed, about one per cent. of a reddish mud, consisting of silica, alumina, and the red oxide of iron. This experiment has been frequently repeated with different samples of *Globigerina* ooze, and always with the result that a small proportion of a red sediment remains, which possesses all the characters of the red clay . . . .

"It seems evident from the observations here recorded, that *clay*, which we have hitherto looked upon as essentially the product of the disintegration of older rocks, may be, under certain circumstances, an organic formation like chalk; that, as a matter of fact, an area on the surface of the globe, which we have shown to be of vast extent, although we are still far from having ascertained its limits, is being covered by such a deposit at the present day.

"It is impossible to avoid associating such a formation with the fine, smooth, homogeneous clays and schists, poor in fossils, but showing worm-tubes and tracks, and bunches of branching things, such as Oldhamia, silicious sponges, and thin-shelled peculiar shrimps. Such formations, more or less metamorphosed, are very familiar, especially to the student of palæozoic geology, and they often attain a vast thickness. One is inclined, from the great resemblance between them in composition and in the general character of the included fauna, to suspect that these may be organic formations, like the modern red clay of the Atlantic and Southern Sea, accumulations of the insoluble ashes of shelled creatures.

"The dredging in the red clay on the 13th of March was unusually rich.

The bag contained examples, those with calcareous shells rather stunted, of most of the characteristic groups of the Southern Sea, including *Umbellularia*, *Euplectella*, *Pterocrinus*, *Brisinga*, *Ophioglypha*, *Pourtalesia*, and one or two *Mollusca*. This is, however, very rarely the case. Generally the red clay is barren, or contains only a very small number of forms."

It must be admitted that it is very difficult at present to frame any satisfactory explanation of the mode of origin of this singular deposit of red clay.

I cannot say that the theory put forward tentatively, and with much reservation by Prof. Thomson, that the calcareous matter is dissolved out by the relatively fresh water of the deep currents from the antarctic regions, appears satisfactory to me. Nor do I see my way to the acceptance of the suggestion of Dr. Carpenter, that the red clay is the result of the decomposition of previously-formed greensand. At present there is no evidence that greensand casts are ever formed at great depths; nor has it been proved that *Glauconite* is decomposable by the agency of water and carbonic acid.

I think it probable that we shall have to wait some time for a sufficient explanation of the origin of the abyssal red clay, no less than for that of the sublittoral greensand in the intermediate zone. But the importance of the establishment of the fact that these various deposits are being formed in the ocean, at the present day, remains the same, whether its *rationale* be understood or not.

For suppose the globe to be evenly covered with sea, to a depth say of a thousand fathoms—then, whatever might be the mineral matter composing the sea-bottom, little or no deposit would be formed upon it, the abrading and denuding action of water, at such a depth, being exceedingly slight. Next, imagine sponges, *Radiolaria*, *Foraminifera*, and diatomaceous plants, such as those which now exist in the deep sea, to be introduced: they would be distributed according to the same laws as at present, the sponges (and possibly some of the *Foraminifera*) covering the bottom, while other *Foraminifera*, with the *Radiolaria* and *Diatomaceæ*, would increase and multiply in the surface-waters. In accordance with the existing state of things, the *Radiolaria* and diatoms would have a universal distribution, the latter gathering most thickly in the polar regions, while the *Foraminifera* would be largely, if not exclusively, confined to the intermediate zone; and, as a consequence of this distribution, a bed of "chalk" would begin to form in the intermediate zone, while caps of silicious rock would accumulate on the circumpolar regions.

Suppose, further, that a part of the intermediate area were raised to within 200 or 300 fathoms of the surface—for any thing that we know to the contrary, the change of level might determine the substitution of greensand for the "chalk;" while, on the other hand, if part of the same area were depressed to 3,000 fathoms, that change might determine the substitution of a different silicate of alumina

and iron—namely, clay—for the "chalk" that would otherwise be formed.

If the Challenger hypothesis, that the red clay is the residue left by dissolved *Foraminiferous* skeletons, is correct, then all these deposits alike would be directly, or indirectly, the product of living organisms. But just as a silicious deposit may be metamorphosed into opal or quartzite, and chalk into marble, so known metamorphic agencies may metamorphose clay into schist, clay-slate, slate, gneiss, or even granite. And thus, by the agency of the lowest and simplest of organisms, our imaginary globe might be covered with strata, of all the chief kinds of rock of which the known crust of the earth is composed, of indefinite thickness and extent.

The bearing of the conclusions which are now either established, or highly probable, respecting the origin of silicious, calcareous, and clayey rocks, and their metamorphic derivatives, upon the archæology of the earth, the elucidation of which is the ultimate object of the geologist, is of no small importance.

A hundred years ago the singular insight of Linnæus enabled him to say that "fossils are not the children but the parents of rocks,"[1] and the whole effect of the discoveries made since his time has been to compile a larger and larger commentary upon this text. It is, at present, a perfectly tenable hypothesis that all silicious and calcareous rocks are either directly, or indirectly, derived from material which has, at one time or other, formed part of the organized framework of living organisms. Whether the same generalization may be extended to aluminous rocks, depends upon the conclusion to be drawn from the facts respecting the red-clay areas brought to light by the Challenger. If we accept the view taken by Mr. Wyville Thomson and his colleagues—that the red clay is the residuum left after the calcareous matter of the *Globigerinæ* ooze has been dissolved away—then clay is as much a product of life as limestone, and all known derivatives of clay may have formed part of animal bodies.

So long as the *Globigerinæ*, actually collected at the surface, have not been demonstrated to contain the elements of clay, the Challenger hypothesis, as I may term it, must be accepted with reserve and provisionally, but, at present, I cannot but think that it is more probable than any other suggestion which has been made.

Accepting it provisionally, we arrive at the remarkable result that all the chief known constituents of the crust of the earth may have

[1] "Petrificata montium calcariorum non filii sed parentes sunt, cum omnis calx oriatur ab animalibus." "Systema Naturæ," Ed. xii., t. iii., p. 154. It must be recollected that Linnæus included silex, as well as limestone, under the name of "calx," and that he would probably have arranged diatoms among animals, as part of "chaos." Ehrenberg quotes another even more pithy passage, which I have not been able to find in any edition of the "Systema" accessible to me: "Sic lapides ab animalibus, nec vice versa. Sic rupes saxei non primævi, sed temporis filiæ."

formed part of living bodies; that they may be the "ash" of protoplasm; that the "*rupes saxei*" are not only "*temporis*," but "*vitæ filiæ*;" and, consequently, that the time during which life has been active on the globe may be indefinitely greater than the period the commencement of which is marked by the oldest known rocks, whether fossiliferous or unfossiliferous.

And thus we are led to see where the solution of a great problem and apparent paradox of geology may lie. Satisfactory evidence now exists that some animals in the existing world have been derived by a process of gradual modification from preëxisting forms. It is undeniable, for example, that the evidence in favor of the derivation of the horse from the later tertiary *Hipparion*, and that of the *Hipparion* from *Anchitherium*, is as complete and cogent as such evidence can reasonably be expected to be; and, the further investigations into the history of the tertiary mammalia are pushed, the greater is the accumulation of evidence having the same tendency. So far from paleontology lending no support to the doctrine of evolution—as one sees constantly asserted—that doctrine, if it had no other support, would have been irresistibly forced upon us by the paleontological discoveries of the last twenty years.

If, however, the diverse forms of life which now exist have been produced by the modification of previously-existing less divergent forms, the recent and extinct species, taken as a whole, must fall into series which must converge as we go back in time. Hence, if the period represented by the rocks is greater than, or coextensive with, that during which life has existed, we ought, somewhere among the ancient formations, to arrive at the point to which all these series converge, or from which, in other words, they have diverged—the primitive undifferentiated protoplasmic living things, whence the two great series of plants and animals have taken their departure.

But, as a matter of fact, the amount of convergence of series, in relation to the time occupied by the deposition of geological formations, is extraordinarily small. Of all animals the higher *Vertebrata* are the most complex; and among these the carnivores and hoofed animals (*Ungulata*) are highly differentiated. Nevertheless, although the different lines of modification of the *Carnivora* and those of the *Ungulata*, respectively, approach one another, and, although each group is represented by less differentiated forms in the older tertiary rocks than at the present day, the oldest tertiary rocks do not bring us near the primitive form of either. If, in the same way, the convergence of the varied forms of reptiles is measured against the time during which their remains are preserved—which is represented by the whole of the tertiary and mesozoic formations—the amount of that convergence is far smaller than that of the lines of mammals, between the present time and the beginning of the tertiary epoch. And it is a broad fact that, the lower we go in the scale of organization,

the fewer signs are there of convergence toward the primitive form whence all must have diverged, if evolution be a fact. Nevertheless, that it is a fact in some cases, is proved, and I, for one, have not the courage to suppose that the mode in which some species have taken their origin is different from that in which the rest have originated.

What, then, has become of all the marine animals which, on the hypothesis of evolution, must have existed in myriads in those seas, wherein the many thousand feet of Cambrian and Laurentian rocks, now devoid, or almost devoid, of any trace of life, were deposited?

Sir Charles Lyell long ago suggested that the azoic character of these ancient formations might be due to the fact that they had undergone extensive metamorphosis; and readers of the "Principles of Geology" will be familiar with the ingenious manner in which he contrasts the theory of the Gnome, who is acquainted only with the interior of the earth, with those of ordinary philosophers, who know only its exterior.

The metamorphism contemplated by the great modern champion of rational geology is, mainly, that brought about by the exposure of rocks to subterranean heat, and, where no such heat could be shown to have operated, his opponents assumed that no metamorphosis could have taken place. But the formation of greensand, and still more that of the "red clay" (if the Challenger hypothesis be correct) affords an insight into a new kind of metamorphosis—not igneous, but aqueous—by which the primitive nature of a deposit may be masked as completely as it can be by the agency of heat. And, as Wyville Thomson suggests, in the passage I have quoted above (p. 17), it further enables us to assign a new cause for the occurrence, so puzzling hitherto, of thousands of feet of unfossiliferous fine-grained schists and slates, in the midst of formations deposited in seas which certainly abounded in life. If the great deposit of "red clay" now forming in the eastern valley of the Atlantic were metamorphosed into slate and then upheaved, it would constitute an "azoic" rock of enormous extent. And yet that rock is now forming in the midst of a sea which swarms with living beings, the great majority of which are provided with calcareous or silicious shells and skeletons, and therefore are such as, up to this time, we should have termed eminently preservable.

Thus the discoveries made by the Challenger expedition, like all recent advances in our knowledge of the phenomena of biology, or of the changes now being effected in the structure of the surface of the earth, are in accordance with, and lend strong support to, that doctrine of Uniformitarianism, which, fifty years ago, was held only by a small minority of English geologists—Lyell, Scrope, and De la Beche—but now, thanks to the long-continued labors of the first two, and mainly to those of Sir Charles Lyell, has gradually passed from the position of a heresy to that of catholic doctrine.

Applied within the limits of the time registered by the known fraction of the crust of the earth, I believe that Uniformitarianism is unassailable. The evidence that, in the enormous lapse of time between the deposition of the lowest Laurentian strata and the present day, the forces which have modified the surface of the crust of the earth were different in kind, or greater in the intensity of their action, than those which are now occupied in the same work, has yet to be produced. Such evidence as we possess all tends in the contrary direction, and is in favor of the same slow and gradual changes occurring then as now.

But this conclusion in no wise conflicts with the deductions of the physicist from his no less clear and certain data. It may be certain that this globe has cooled down from a condition in which life could not have existed; it may be certain that, in so cooling, its contracting crust must have undergone sudden convulsions, which were to our earthquakes as an earthquake is to the vibration caused by the periodical eruption of a geyser; but in that case the earth must, like other respectable parents, have sowed her wild-oats, and got through her turbulent youth, before we, her children, have any knowledge of her.

So far as the evidence afforded by the superficial crust of the earth goes, the modern geologist can, *ex animo*, repeat the saying of Hutton, "We find no vestige of a beginning—no prospect of an end." However, he will add, with Hutton, "But in thus tracing back the natural operations which have succeeded each other, and mark to us the course of time past, we come to a period in which we cannot see any further." And if he seek to peer into the darkness of this period, he will welcome the light proffered by physics and mathematics.—*Contemporary Review.*

## EVOLUTION AND THE AFTER-LIFE.

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FEW persons are able to escape some form of belief in the existence of a soul. Whatever view we may take of its origin, gradations, or development, whether the infinite soul, the human, the animal, and the "soul of things," are each only manifestations in different degrees of the same great principle, or each enlargement and refinement in the ascending series is to be considered a development, or whether nothing is to be dignified as soul except that which is manifested through human forms—whatever views we may have regarding its limitations and destiny—we cannot escape the conviction that there is, in man at least, a distinct entity, a combination of faculties, a blending of sensation, will, and wisdom, which we call soul. Its powers, its modes of action, and its destiny, have been subjects of

thought for the thoughtful of all times. Gradually these thoughts have taken form, and a science of psychology has grown up, engaging in its investigations the efforts of the ablest minds.

It may not be reasonable to suppose that any being, unless it be the Infinite, should perfectly comprehend itself. How far man is from being able to claim such knowledge may be inferred when we consider that, although he has been upon the earth so many thousand years, it is less than three centuries since he began to understand even his physical organization, or comprehend such simple facts in his own physiology as the process of digestion and the circulation of the blood. It is only within the present century that the functions of the nervous system began to be understood, and only within the last few years that its relations to mental activity have been intelligently studied. With so many points in regard to the functions of the material body only recently understood, and even now but imperfectly known, is it strange that our psychical relations should be even less perfectly comprehended?

A recent writer[1] has pointed out the fact that each epoch of intellectual activity and enlargement, as marked by the discovery of new truths in Nature, has been accompanied or directly followed by better modes of investigation and more scientific views in psychology; and not only so, but the methods employed and the results obtained in psychology have had direct relation to the methods and results in physical science. As mathematics and the laws of motion gave us Descartes and Hobbes, scientific medicine or the "science of observation" Locke, the vibratory theory Hartley, and chemistry the elder Mill, so geology and the doctrine of evolution have been potent in influencing the methods and results obtained in psychology by Bain and Herbert Spencer. And as each advance in psychology has had reference to the methods in physical science which have preceded it, so do we find that the doctrine of evolution, which in its general aspect at least has given direction to the scientific thought of the present generation, has also been the doctrine which has thrown most light upon the constitution and action of mind.

It is not the object of this paper to discuss the doctrine of evolution, but simply in the light of that doctrine, as generally understood, to present such facts as science has prepared for us relative to the development of mind, and its manifesting organs in the gradually-ascending series of animal forms.

The organ of all psychical manifestation is the nervous system, and the material of which it is composed is substantially the same, whether in animals of a high or a low organization. It is of two kinds, the *gray matter*, usually found in nodules or masses of greater or less bulk, called *ganglia*, and the *white matter*, usually found in

[1] "The Development of Psychology," *Westminster Review*, and POPULAR SCIENCE MONTHLY, July and August, 1874.

continuous lines, and called *nerve-trunks*, or simply *nerves*. The ganglia are the *centres of power*. The trunks are the *lines of communication* between the ganglia and the different parts of the organism.

Without descending into the debatable ground between the vegetable and animal world (for, strange to say, the boundary-line between two modes of life apparently so different has never yet been established), let us examine an organism as lowly as any possessing a distinct and single nervous system—an ascidian mollusk—which simply means a bag-shaped, soft-bodied animal. It has no head, nor any

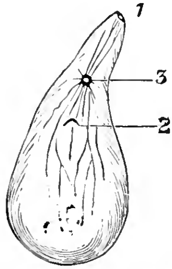


Fig. 1.—Nervous System of Ascidian: 1. Mouth; 2. Vent; 3. Ganglion.

organs of sight, hearing, or smell. It consists of a sac, from the lower portion of which proceeds a stomach or digestive tube; these are covered with a muscular envelope, and the whole is inclosed in another envelope or membranous sac called a mantle. These coverings are pierced by two openings—a mouth for admitting water and the nutrient particles which it happens to contain into the inner sac or common reservoir, which also serves as a respiratory organ—and a vent, communicating directly with this sac, and also with the more circuitous digestive tube. A constant stream of water passes through the mouth into this common or respiratory sac, where, after having served its purpose of supplying oxygen to the system, a part is ejected directly through the vent, and the remainder, together with the nutrient particles, passes into the digestive tube, and thus finds its exit.

The nervous system, which is the part most important to our present purpose, is of the most simple kind; it consists of a single ganglion, situated between the two orifices of the body, with each of which it has lines of nerve-communication, and also with the various envelopes which mainly constitute the animal.

All the creature's movements must be carried on by means of this simple nervous arrangement; and, as it is fixed to one spot during its whole life, they must necessarily be of a very limited character; it has, in fact, but one movement—it contracts when touched.[1] Suppose, for instance, some offending substance to have found its way into the common sac, the *irritation* caused by it is transferred along the

[1] For many of the facts and illustrations here stated, see "Mental Physiology," by Dr. Carpenter, chapter ii.

communicating nerves *to* the ganglion; there a "motor impulse" is generated, which again is transferred along the communicating lines *from* the ganglion to the muscular envelope, causing it to contract and eject the water which it contained, together with the offending substance. This is all the action the creature is capable of, and this it repeats whenever and wherever an irritation is applied. It is the simplest action, so far as we know, requiring a nervous system for its accomplishment, and has received the name of *reflex action*.

Without following each shade of improvement in the nervous organization of the mollusks, or soft-bodied animals, it may suffice to say that the same general arrangement holds throughout all the lower members of the series, new ganglia being added to meet the needs of a more complex organization until, in the highest members, as, for instance, in snails and the cuttle-fish, important changes are found to have occurred. Instead of the headless and irregular masses which have constituted the bodies up to this point, we now find an animal comparatively symmetrical in form, with a distinct head, and imperfectly-developed organs of special sense. Here, then, occurs the division between the two great classes of animals known as *cephalous* and *acephalous;* all the lower species of mollusks, the ascidians, mussels, oysters, and the like, belong to the acephalous or headless class, while with the highest species, snails, the nautilus, and the cuttle-fish, commences the other great class known as cephalous animals, or those having distinct heads.

The advance in the nervous system is correspondingly great; instead of the irregularly-situated ganglia hitherto met with, we find them arranged in pairs, to serve the purposes of the more symmetrical body; but a still more marked and important advance is found in the fact that each organ of special sense (sight, hearing, etc.) is furnished with a separate nerve-centre or ganglion; all of which, being brought together in the head of the animal, constitute what is known as the *cephalic ganglia*, or *sensorium*, an incipient brain.

The function of this nervous system is not merely to respond to irritation applied directly to the body, but also to respond to certain stimuli, such as that afforded by sight and hearing, received at the sensorium through the organs of special sense, and thence transferred to the different ganglia. This new stimulus is called *sensation*, and it is one to which the ganglionic system responds with almost the same alacrity that it does to direct contact.

Leaving now the grand division of mollusks, we ascend to another division in the animal world, namely, the *Articulates.* It embraces such marine animals as the crab, lobster, and crayfish; and on the land, worms, centipedes, and all the numerous tribes of insects. The characteristic of the whole division is, that the body is made up of rings or segments, joined and moving one upon the other, and hence the name *articulates.*

The general plan of the nervous organization throughout this large division is that just described, and commencing with cephalous animals. It consists of symmetrically-arranged ganglia—a sensorium, and the necessary communicating nerves.

And what are the actions by which this improved nervous system, characterizing all this large class of animals, manifests itself?

Taking the two extremes in the class of well-characterized articulates, the centipede at the lower, and wasps and bees at the upper, we notice a wide difference in the complexity of the general organization, and a difference equally marked in the character of the corresponding actions. In the centipede, the general structure consists of a head furnished with certain organs of special sense, and a body made up of a series of segments—each, with the exception of the last, being a repetition of the others, and each being furnished with a single pair of legs.

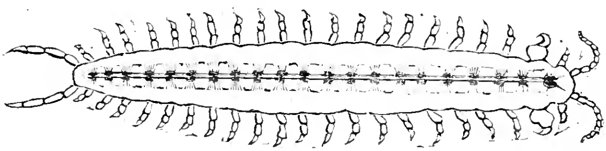

Fig. 2.—Sensorium and Connected Ganglia of Centipede.

To preside over these organs of locomotion, the nervous system is distributed as follows: Each segment is supplied with a double ganglion, or nerve-centre, all being arranged in regular order just beneath the alimentary canal, and in the head is placed the sensorium; all the different ganglia are connected by a fine double-nerve filament called the *ventral cord*, and through this means also all are in communication with the sensorium. So each ganglion is in communication with its own particular pair of locomotive organs, with each of the other ganglia, and with the sensorium.

The chief action of this animal consists in the movement of these organs of locomotion; and this it does in response to direct irritation from without, or in consequence of *sensations* received at the sensorium through the organs of special sense, and thence transmitted to the several ganglia. So long, then, as this nervous communication remains unbroken, the action of all the segments composing the body is harmonious, and is performed with a direct relation to the guiding influence of the sensorium. This is the normal action of the animal. But suppose, now, that the head, with the sensorium, be removed while the creature is in motion, the legs still perform their office, carrying the body forward in its accustomed manner until it meets an obstruction, when its progress is stopped, though the legs still continue to move. If the body be divided, similar results follow: the forward part moves on under the guidance of the sensorium, avoiding or overcoming obstacles according as sight or other sensations influ-

ence; the after-part of the divided body also moves on, but only in obedience to its own ganglionic centres, and without any guidance from, or relation to, the sensorium, or the anterior portion of the body.

Thus we see the ordinary movements of the animal continuing to be repeated with only that part of the nervous system in operation which is capable of producing *reflex action.* What the entire creature has been *accustomed* to do, the separate parts continue to do when cut off from the guiding influence of the sensorium. The same holds good even in some of the more highly-organized members of the articulate series. A remarkable instance is given by Dr. Carpenter, as shown in the *mantis*, an insect allied to the crickets, which performs its accustomed and very peculiar actions not only when the head is removed, but the segments of the body perform each its accustomed part, and no other, when the body itself is divided. So also a certain kind of water-beetle, after the sensorium is removed, remains motionless so long as it rests upon a dry surface; but, being placed upon the water, its accustomed element and stimulus, performs its accustomed movements of swimming, and with such energy as to strike aside its companions with great violence. These motions, which are repeated, as has been seen, under the influence of the ganglionic system alone, and by the simple process of reflex action, are termed *automatic;* and when these actions, though often more complex and varied, are repeated in the same automatic manner under the guidance of the sensorium, and under the stimulus derived from sensation, they are called *instinctive.*

Coming, now, to the higher species of articulates, we find the so-called social insects, and especially bees, furnishing the most wonderful examples of instinctive action; they construct for themselves habitations, some of them involving nice principles of geometry; they store up food for future use, and their whole economy seems, at first glance, to demand the presence and aid of even a rare intelligence; yet, on examination, it is found that no teaching is required, no thought nor memory is brought into use in these remarkable actions, but each insect goes to work without direction and without individual experience, and does at once, without hesitation, the first time as well as ever, that which is in its nature to do. "It acts according to its nervous organization."

How the insect comes by this *impulse to do*, is one of those seemingly simple questions which, in reality, includes the whole; it is the ever-recurring question regarding each new faculty as it makes its appearance in the series, and demands a few words in reference to the main theories involved. The term *instinct* is not to be taken, in its popular sense, as referring to all the actions performed by animals in distinction from those performed by man, but must be limited to those automatic actions which are performed without teaching or individual experience. Now this impulse, or instinct, as exemplified in the bee,

must, as was formerly supposed, have been directly impressed upon the nervous organization at the creation of the first bee, and transmitted by each succeeding generation, or, as contended by Herbert Spencer and others, the race must have become gradually endowed with it, by a constant repetition of those acts which each individual was stimulated to perform by its surroundings at succeeding times. The former method presupposes a *special creation* and endowment for each species of animals; a supposition generally rejected by scientific men as presenting insurmountable difficulties, and as not having facts within possible reach to sustain it; for no one has ever known of a special creation. The other method presupposes *development* in some of its various phases, which, although not without its difficulties, satisfies so many existing conditions, and is constantly helping to solve so many formerly insoluble problems, that scientific men are led to adopt it, provisionally at least, as probably true in its main features, and certainly of great importance as an aid in further investigations.

According to this theory, instinct is the aggregate or accumulated experience of each race of creatures in which it is found—is impressed by repetition upon the nervous organization, and is inherited alike by each individual of a race, causing their actions to be the same, generation after generation, unless changed by necessity from changed surroundings. This is the mode of action characterizing the large class of animals whose highest nervous development is the sensorium. It embraces the cephalous mollusks and the whole division of articulates; and its highest development is reached in insects.

Ascending now another step in the series of animated forms, we find again an advance in the nervous organization suited to the still more complex action and consequent needs of the animal.

Without following out in detail the gradations which take place in passing from the articulate to the vertebrate series, we find in general terms the following changes to have occurred; and, as an example, one of the first and simplest of the series may be taken, namely, the fish. Instead of the *ventral cord*, with its interrupted series of ganglia, as in the centipede, we find in the fish a *spinal cord*, existing as a continuous line of ganglionic matter, inclosed in a fibrous sheath of white conducting matter, and the whole protected in the bony canal formed for it by the beautifully-arranged pieces which make up the *vertebral column*, or back-bone. From this continuous ganglionic centre nerves are given off at different points, as they are needed to supply the different muscles of the body, and especially those of locomotion. We find the sensorium enlarged to preside over the improved organs of special sense, the optic ganglia still being much the more important; and we have two *new* ganglionic masses *added*, the *cerebrum* in front of the optic ganglia, and the *cerebellum*, placed just behind them. Concerning these, it may be remarked that the latter, although its function has not been so clearly demonstrated as many

other portions of the system, shows such marked relations to the complexity and perfection of the movements of which any animal is capable, as to render it nearly certain that its use is to regulate and coördinate muscular action; while the former, as marking a grand advance in the psychic endowments of living creatures, constitutes the most important addition to the nervous system hitherto found.[1]

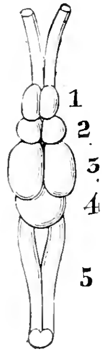


FIG. 3.—BRAIN OF FISH: 1. Olfactory Ganglia; 2. Cerebral Ganglia; 3. Optic Ganglia; 4. Cerebellum; 5. Spinal Cord.

Here, for the first time, inclosed in its bony covering, we have an organ possessing, even in a rudimentary form, the principal parts of a complete brain. Of these parts the cerebrum, which is found as merely rudimentary in the fish, now takes the precedence in interest and importance—from fishes to reptiles, from reptiles to birds, from birds to mammalians, and all through the mammalian tribes, from the imperfect marsupial upward to the anthropoid apes and man, we find in the main, an unbroken line of increase in cerebral development, and corresponding increase in intelligence.

Then, again, it is of interest to inquire the manner in which this new faculty, intelligence, makes its appearance along with the improved nervous organization, and how it differs from the instinct of the classes below.

According to the eminent authority before referred to, as instinct is the aggregate experience of the *race*, accumulated and impressed upon the nervous system by innumerable repetitions, inherited by each individual of the race and available all at once, so intelligence is the aggregate *individual* experience and is available only as acquired, though the facility for acquiring it varies according to the nervous organization. Both instinct and intelligence may exist in the same individual, but generally, in proportion as actions governed by intelligence become numerous, those governed by instinct decrease in number and importance. In observing the nervous organization of the

[1] As expressed by Mr. Fiske, in his "Cosmic Philosophy," the cerebellum presides over *space* relations, while the cerebrum presides over *time* relations.

centipede as the representative of a dawning instinct and its appropriate manifesting organ, the sensorium, it was found that reflex action, characteristic of acephalous animals, did not cease when the head and its special ganglia appeared, but that a large share of its actions was still purely reflex in character, even those prompted by its small and imperfect sensorium being but little raised above the reflex and into the region of instinctive actions; and that the ganglionic system and reflex action were continued all through the higher mollusks and the whole series of articulates, only diminishing in importance as the sensorium and instinctive action increased. So in the commencing vertebrate series, we find the nervous organization of the preceding races continued—that for reflex action being represented in the spinal cord, and that for instinctive action being continued in the sensorium; not only so, but in proportion as the cerebrum remains small and undeveloped, and the sensorium predominates, do instinctive actions remain in the ascendant both in number and importance. This is found to be true in all the lower orders of vertebrates—fishes and reptiles; and even in the lower mammalians, although the cerebrum may outweigh the other portions of the brain, still a very important part of the actions manifested is instinctive. As an example of this in birds,

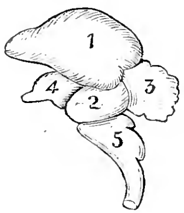


Fig. 4.—Brain of Pigeon: 1. Cerebrum; 2. Optic Ganglia: 3. Cerebellum; 4. Optic Nerve; 5. Spinal Cord.

may be mentioned the chick, which breaks its prison of shell with its beak and immediately runs about, sees and picks up its particle of food with unerring certainty without teaching or experience, hears and answers the call of the mother-bird, and scrambles toward her for protection although it may never have seen her. Birds also possess in a remarkable degree the impulse, akin to that of insects, for preparing elaborate habitations; but unlike the insect races they add a certain degree of intelligence to their work, varying it in form and material according to locality and surroundings, and even finishing for their own use that which others had left incomplete and abandoned. In proportion as instinct ceases to predominate, the work becomes less uniform; and so it may be observed in general, that in proportion as the habits of a given race are fixed and automatic, does each individual conform in its action to that prearranged method, and we know what each individual under given circumstances will do; but, as intel-

ligence increases and a larger range of actions is performed, this power to predict how any individual will act is gradually lost.

Advancing step by step upward in the mammalian series, certain changes in the development of the cerebrum occur, accompanied in each instance by the introduction of new faculties or the improvement of old ones. Throughout the lower orders—fishes, reptiles, and birds—the cerebrum, though constantly increasing in relative size from mere nodules of gray matter less in size than the optic ganglia, up to masses of much greater bulk than the sensorium, still retains the same general appearance—two smooth oval bodies, one on each side of the median line, and gradually approaching each other as they enlarge until they meet, then extending forward and backward so as more and more to cover in and hide the sensorium. These represent the *hemispheres;* and this is the condition of brain which is found in the lower mammalians. Associated with this cerebral development we find a psychical condition not very far advanced beyond that already considered as pertaining to birds; namely, action partly prompted by instinct, and partly controlled by intelligence, as especially seen in the *rodentia*, or gnawing animals. The perfection of instinct and want

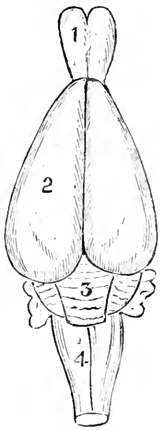


FIG. 5.—BRAIN OF RABBIT (*Rodent*): 1. Olfactory Ganglia; 2. Cerebral Hemispheres; 3. Cerebellum; 4. Spinal Cord. Other parts of Sensorium covered by Cerebrum.

of reasoning power in regard to certain actions are well illustrated in an example quoted by Dr. Carpenter. It is that of a beaver which a gentleman kept in his house, and who, notwithstanding his unfavorable surroundings, would exercise his instinct for dam-building on all occasions; for materials he appropriated brooms, warming-pan, walking-sticks, baskets, boots, and books, or in fact any thing portable within his reach, arranging them in the most approved style of beaver architecture, although he had never witnessed the process in others. He exercised the same skill, also, in preparing himself a dwelling. The absurdity of the whole process from a *reasoning* point of view

was obvious from the fact that he had no access to water, and was already comfortably housed. He was simply working out what was impressed upon his nervous organization by countless generations of dam-builders before him, independent of circumstances or uses. In this class, however, are commenced two grand improvements in the cerebral development: first, the uniting of the two parts constituting the hemispheres by a broad band of fibres, known as the "*great transverse commissure*," indications of which appear in the rodents; and, second, "indications of a '*middle lobe*' marked off from the anterior by the fissure of Sylvius." To these soon are added the "*convolutions*," or corrugation of the outer or cortical layer of the hemispheres, so as to secure more surface of active nerve-material without additional bulk; and lastly, in the apes, appears the commencement of the *third* or "*posterior lobe*."

In the human brain no addition of parts is presented, but only improvements in those parts found in animals next below. One of these improvements is the more perfect communication established between the different parts composing the brain; the great "transverse commissure" connecting the two hemispheres is much better developed than in any of the preceding races, also the fibres connecting the cerebrum with the sensorium upon which it lies; the "convolutions," only indicated by slight depressions even in monkeys and apes, become conspicuous in the human brain, giving it the appearance of being gathered up in deep folds; and the "posterior lobe," which, as we have seen, first makes its appearance in the highest apes, is much increased in man, even in the uncultivated tribes, as is also the comparative bulk of the whole cerebrum.

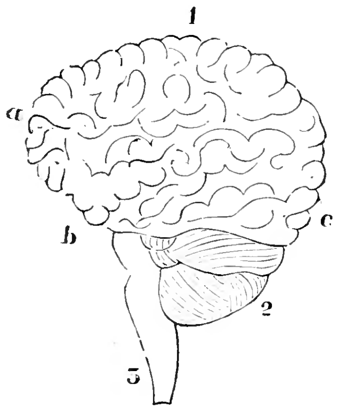


FIG. 6.—HUMAN BRAIN: 1. Cerebrum; 2. Cerebellum; 3. Spinal Cord. Sensorium covered by Cerebrum; *a*, *b*, *c*, Anterior, Middle, and Posterior Lobes of the Cerebrum.

These various improvements, gradually succeeding each other, are accompanied by psychical developments equally marked; gradually the strong instincts and limited perception of surroundings, which

tend to make all the individuals of a class alike in physical and pyschical endowments, give place to more complex sensations, gathered from a wider range of surroundings. The cerebrum begins to take cognizance of these sensations, and to give its approval, before they are translated into actions; memory dawns—hatred, fear, anger, and revenge, are born; a certain adapting of means to ends gives evidence of commencing reason; affection, love of approbation, joy, and sorrow, all these appearing in the races most associated with man, proclaim the presence of faculties and endowments far above the plane of mere instinct, and bordering close upon attributes usually applied to *soul* alone, and in its more dignified estates.

Examples of such endowments in the brute races can hardly have escaped the notice of any intelligent observer. In the faithful dog, who at a word from his master collects the stray flock in the stormy Highlands, or brings in the helpless and perishing traveler from the snowy Alps; who shields his child playmate from the passing danger, or rescues him from threatening death; who, himself hungry, guards food for others; who with quick perception notes and shares his master's varying moods, and who metes out justice for the weak against the strong, we behold in humble guise a dawning soul, with which no truly noble soul need wish to ignore kinship.

To note all the improvements in the physical organ of mind in man, and point out the vast psychical advances which are found in him, compared with the best of the races beneath him, would far exceed our limits. We may, however, notice here that, as in his nervous organization, no distinctly new parts are discoverable, but only general growth and development, and especially vast increase in the size and working capacity of the cerebrum, together with improved lines of communication between the different parts of the brain, so in the psychical manifestations which this enlarged and better-developed brain exhibits, no faculties are discovered beyond what these various developments in structure render possible. Does man possess intelligence? It is found also in the lower tribes. Memory? Many races of animals possess it. Reason? No definition of it can be formed, consistent with its exercise in man, which can debar it from some feeble exercise in his more lowly companions. Up to the point which their organization permits, they possess and exercise faculties akin to those of man. But it is in the degree and perfection to which these faculties attain that the superiority of man is evident; and here the difference is vast indeed. The intellectual superiority of an ordinary man over the most sagacious animal, which nevertheless can scarcely be taught the simplest relation of numbers, is too vast to be readily comprehended; but so is the difference immense between the reasoning powers of an infant and a man, or a Hottentot and a Cuvier or Laplace. If a dog cannot be taught simple arithmetic, neither can a Hottentot be taught optics nor analytical geometry, nor be made to

take in the idea of "quantitive reasoning" nor "correlation of forces." The dog is capable of improvement, limited only by his organization; the Hottentot only by his, and the child of a large-brained and cultivated ancestry by his. The difference in these possibilities, however, can only be comprehended upon reflection. The most intelligent animal, or even the savage man, bears relations to no surroundings beyond the mere *seeming* of things upon the few acres or miles traversed by his race or tribe; the sun and moon are only what they appear; they rise just beyond the mountain, and they go down in the forest. The thunder and the tempest are incomprehensible, or are the voice and breathings of an angry God. The philosopher, or man of science, on the contrary, holds converse with all objects, animate and inanimate; all peoples and their works, both present and past, upon the surface of the earth. He explores its depths, and calls up before him the generations which peopled it ages on ages past. The microscope brings before him the world of the infinitely small, and the telescope reveals the worlds of space. With the spectroscope he questions the stars, and they give intelligible reply. Such, and a thousand-fold more, are his surroundings; and it is to express his relations to these, to the complex impressions and sensations to which they give rise, and the reflections and aspirations which they inspire, that the brain of the philosopher must be adequate.

We have thus noticed the more prominent structural changes as they occur in the nervous system, from its simplest form to its highest development, and also the corresponding psychical manifestations, which each advance in structure rendered possible. We have seen the lowly creature, endowed with its single nerve-centre, and its radiating nerve-filaments, expressing all its relations to the outer world by simple *reflex action;* and, if, as we should expect, the order of appearance in Nature corresponded with the order of development, for untold ages all over the silent, ocean-clothed earth, no higher form of life, and no higher expression of soul, was present. Gradually, by many a minute addition, in response to improved surroundings and new requirements, new organs appeared, until at length there existed a creature of definite form, with organs of sight and hearing, as well as touch and locomotion. The old ganglionic nerve-system, with its simple reflex movements, was still retained; but, to express the many new relations to the outer world which its gradually-acquired organs made possible, additional nerve-centres were required, and the *sensorium* assumed form and use. The series of actions performed through its promptings we call *instinctive*. Then for unknown ages sense-impressions, stimulating to instinctive action, were the highest expressions of soul upon the slowly-emerging earth.

But, again, improved surroundings—the dry earth, with forest, field, and flower, the brighter sunlight and the purer air, demanded new organs to appropriate and new senses to enjoy; and a race ap-

peared with improved organs of sense to receive impressions from this better outer world, improved modes of action, and above all in place, and superior to all in function, an organ of intelligence was added. The old methods of soul-manifestation continue; both reflex and instinctive action find their appropriate place in the higher organization; but they are not sufficient for the numerous and complex relations which now existed between the creature and the outer world; then the cerebro-spinal system comes into being, consciousness becomes perfected, intelligence established, and reason dawns.

Again, ages elapsed in gradual changes, until at length man, the crowning excellence, appeared—an upright form, a powerful brain, a soul capable of tracing causes, and even seeking to find out the First Cause. He was the first to place an ideal—his highest conception of good—before himself, and say, "Now for this will I strive;" the first of all the long line of sentient beings to aspire after a higher life; the first to say within himself, "I shall die," or ask, with ever-increasing interest, "Shall I live again?"

And what is the relation of science, especially as represented by the doctrine of evolution, to this aspiration after a future life? The objections raised against the doctrine by the religious world—the uninstructed part, at least—are that it banishes Deity and tends to materialism.

If by banishing Deity is meant that conception of him which particular sects or peoples have obtained, and are each desirous that all the world should have, the objection may or may not have foundation; but, if it is meant that the doctrine shuts out a great first and adequate cause for all the grand and orderly series of events and existences in Nature, nothing could be further from the truth. The desire to seek for causes is one of the developments of the human mind, increasing in direct ratio with the increase of intelligence. Brute intelligence exhibits no such desire. The savage mind does not rise far into that sphere of intelligence which demands causes; it is only as a higher reasoning power dawns that analysis commences, and causes are sought after; and the higher the intelligence and stronger the power of reason, the more imperative the demand for causes, and the more perfect the comprehension of them.

What is true of causes in general is true in a still greater degree of remote causes, and of a first cause; and hence that which we should expect to occur is found to be the fact, namely, that the scientific men of the present time, the well-developed and well-cultivated minds in all departments of learning, but especially in physical science, are the ones most fully established in an intelligent belief in an adequate first cause. The time is past in which the feeblest artificial works found upon the surface of a single planet, even to the flint-hewn weapons of an unknown race, must have assigned for them a competent originator, and yet man himself, with his complex organization, the long line of organ-

isms of which he is chief, the planet on which he dwells, the system to which it belongs, and the whole vast system of systems sweeping in unimagined circles through space, all be supposed to exist, and have no architect and no supporter. Such is not the deduction of science, and such is not the conclusion at which the most skilled interpreters of Nature have arrived. In examining any artificial work, it is an instinct with man, and his reason approves, to assign for it a conscious and intelligent cause; and he knows that the cause exists in *mind*, for without mind nothing could be planned or originated. Not only so, but in every instance we judge of the *character* of the originating *mind* by the product. A great and noble work is not originated by a feeble and undeveloped mind, nor a crude and imperfect work by a large and well-disciplined one.

We judge similarly in regard to every work, from the crude utensils of the "cave-dwellers" to the mighty products of a Michael Angelo, a Shakespeare, or a Laplace. So, in judging of works compared with which the mightiest works of man are as mole-hills, whose beauty it is the highest exercise of his genius feebly to copy and represent, whose method and arrangement it is the life-work of the most exalted intellects to discover, and whose extent, either in time or space, he still gropes to find the unit of, we assign for cause a corresponding soul; and he who comprehends best the work is capable of understanding best the architect.

The gods of sects and specialties may perhaps be failing of their accustomed reverence, but, in the mean time, there is dawning on the world, with a softer and serener light, the conception, imperfect though it still may be, of a conscious, originating, all-pervading, active soul—the "Over-Soul," the Cause, the Deity; unrevealed through human form or speech, but filling and inspiring every living soul in the wide universe according to its measure: whose temple is Nature, and whose worship is aspiration.

Science, then, so far from excluding God from the universe, demands him as an ever-active power; but, as man can only know him through his works, and as the universe is yet comparatively unknown to him even in his highest condition, and must remain so while he is confined to earth, it follows that our knowledge, and even our conceptions of him, must be limited and imperfect, and our appreciation of him correspondingly so.

Is there, then, reason, in harmony with science, to expect an existence under more favorable circumstances for a knowledge and appreciation of this originating soul whom science itself demands?

As interpreted by the doctrine of evolution, we find man, as he now exists, with his physical organization and advanced psychical being, the product of a long series of developments. He has arrived, however, only at a certain point in the ascending series; from that point he easily reviews the whole long line beneath him from the very

beginnings of organization and life, and admires its grand and orderly procession; but, reaching out forward, he seems to find nothing within the scope of his physical senses. He sees, however, that the series is not ended, for reason assures him that even for the material universe there is, somewhere beyond, an architect whose skill and wisdom he is only commencing to appreciate, but still more, when he beholds the gradual unfolding of the world of soul, with its instinct, consciousness, intelligence, memory, reason, feeling, and aspiration, and considers the possibilities which still may lie enfolded there, is he lost in admiration and wonder at the great centre-soul, the author of all these attributes. And what is to span over the abyss, or even reach out toward this ineffable soul? Is he himself to cease when the material organization wears out?—and consciousness, memory, reason, and, higher, nobler and purer than all, heaven-born aspiration, the crowning development of countless ages, do they all go out in darkness just at the dawning? or, rather, do not the organization of elements and their development into life and movement, the gradual dawning of instinct and reason, and, lastly, of an aspiring soul, give promise of further development under more favoring circumstances for approaching, knowing, and appreciating the great central, causal, all-pervading soul?

For scientific proof of this after-life and future development, the whole world is looking, nor is there any thing unreasonable in the expectation. The orderly steps in the series of development suddenly end with the birth of a soul capable of inquiring after its Author, and aspiring to a continuous life. *Is* it, then, the end of the series, or must there not be further steps approximating toward the central soul, and observers have not searched aright, or means of observation been imperfect or misused? As, in our solar system, the "law of distances," found to exist among the planets, caused astronomers to look for another body in the huge space between Jupiter and Mars, who were rewarded by the discovery of the Asteroids; or as perturbations in the motions of Uranus caused them to look for a planet beyond its orbit, and Neptune was found; so, with equal reason, may psychologists infer the existence of a whole series of superior beings reaching onward toward the Infinite; and who shall deny the possibility of their discovery? The development of man is constantly leading on to the appreciation of more and more subtile elements and effects; the laws which govern the atmosphere—light, sound, and magnetism—which could not have been understood in the infancy of the race, are being unfolded; colors which our remote ancestors could not perceive, are being differentiated; and sounds, which to them were unmeaning noises, or were not discerned at all, to our more refined and better-developed senses convey impressions of pitch and harmony. Such advance in the development of the ordinary senses, not to discuss the possibilities of an internal and still higher sense, gives promise of

future known relations to that which is subtile in the domains of biology and psychology, beyond that which has hitherto been attained.

In this view Science need not despair, and has no right to give over its efforts nor neglect its opportunities to obtain appreciable evidence, however slight it may at first appear, of a future life—one which the doctrine of evolution demands should be a higher development, one of greater possibilities than this. The aspiration after such a life is as much a development of the soul as is intelligence, or reason, or a desire to know causes, and there is the same reason to believe that it has its foundation in a corresponding reality.

And, great as have been the triumphs of science hitherto—great as has been the light which the grand thought of evolution has thrown upon the whole plan and system of the universe—nothing hitherto accomplished could compare in grandeur with the physical demonstration of a higher mode of life and action than that attainable with our present organization and present limitations; a demonstration which would enable man to lie down to sleep with the *knowledge* that he will awaken to an enlarged and ever-enlarging, conscious, future life.

## ADDRESS TO MEDICAL STUDENTS.[1]

By Rev. E. A. WASHBURN, D. D.

I AM glad of the privilege, gentlemen of the Medical College, of meeting to-day so many who are masters and students in the school of science. For if, as I believe, all our studies, whether of Nature or mind, are only chapters of one book, there can be nothing wiser in our day, when the growing mass of learning almost compels a microscopic research and somewhat of a microscopic bias—nothing wiser than at times to interchange our points of view. It is, indeed, one of the phases of that heredity, of which so much is said at present, that our callings bequeath their mental habits, so that the clergyman seems often born without the power of inductive reasoning, and the naturalist with a suspicion of all that cannot be analyzed by his blow-pipe. Yet I am sure that you are of a larger school than this; and in that feeling I venture to put before you a few thoughts on the mutual relations of scientific culture. I shall not try your patience by a treatise on the Mosaic cosmogony or evolution; and, indeed, I must ask your allowance beforehand, if I betray in my remarks that surface knowledge of gases or nervous tissues, not strange to one more busied with Greek aorists and primitive-church deposits. It is your noble calling to be students in that branch of science, perhaps the most fruitful of

[1] Delivered recently to the graduating class of the New York College of Physicians and Surgeons.

discovery to-day, which explores the laws of the highest organic life. If I can point out a few of the common features which give a meeting-ground with you for one who is, like myself, a physician of the soul—for studies that bear on the riddles of our mental life and the largest aims of moral education—my essay will not be thrown away.

It is plain to all that the marked feature of our modern culture is the enthusiastic study of Nature; and the fact demands our impartial thought. This change, even within the last thirty years, is a striking one. It comes in part from the magnificence of the discoveries gained in every part of natural inquiry. It comes again from the reaction of the mind, after a time of overstrained ideal pursuits; nor is it strange, when the philosophy which began with noble thinkers had evaporated at last into a misty pantheism, that we should ask a more robust sense, and a positive knowledge. It is amusing to meet to-day those who awhile ago were talking of the infinite soul in man, and are now quite proud of their pedigree from a West-African ape. But I attribute this feature of our culture not merely to such reaction. It betokens a solid growth in the method of inquiry. Although I distinguish it from many of the theories which call themselves science, yet the principle which begins with the study of facts, verifies them by sure experiment, and rests in ascertained laws, is the key of all discovery. Our modern intellect did not, indeed, originate it. Nor can I ever admit that the great thinkers of the past have not done immeasurable service in their spheres of knowledge; rather, I claim that there is not a single foundation truth, in regard to the mind or moral nature, which was not known, even before a Plato or an Augustine. Our philosophy does not give essential truth; it only opens it in its clearer relations. The fixed stars have shed the same light aforetime, although the glasses of to-day have pierced into the nebulous fields. But it is the peculiar character of natural science, and the grandeur of its march on this high-road, which have established, as never before, its critical method. You are familiar with this in the wide range of inductive study. The knowledge of the heavens is quite another thing to us than in the day when Aristotle reasoned from the ideal perfectness of the circle to the planetary motions; and "made the world," in Bacon's phrase, "out of his categories." Or, to illustrate from your own field, the ancient theories of material and spiritual substance, which led to such fruitless speculation even to recent days, have been exchanged for exact analysis.

But this method is not confined to the interpretation of Nature; it is the common law of advance in all knowledge. Mental science must now begin with the related facts of biology and psychology, in order to rise by clear analysis to the laws of thought or will. History obeys the same principle, and it has so passed, since the day of Niebuhr, out of the cloud-land of legend to *terra firma*. Our vast researches into language have come from the dismissal of the old

hypothesis of a primitive tongue and the correlation of all the facts gathered from all the kindred forms of speech. It is the same with social science. And although I am aware of the notion of many doctors, both of divinity and medicine, that theology is a fixed deposit, as distinct from inductive knowledge, and indeed that there is an eternal conflict of religion and science, yet I am bold to say that it is a vulgar error. There is a more palpable movement in the science of Nature, because it has to do with material forces, while the theologian explores the more subtile laws of thought and moral history. We do not deal with scalpel or microscope, yet we recognize the method of analysis. It might be a curious pursuit if you should study medical history from the day of Galen, through the middle age, and note how the same speculative notions of soul and body entered into the current dogmas of the Church and the healing art. The central truths of Christianity are always the same; but Biblical criticism, the comparative study of Hebrew or Christian epochs, the domain of doctrinal thought, are growths of the human mind, and every advance has been the fruit of experimental searching. And if we have some clergymen as guiltless of modern ideas as the Englishman who moved the risibles of a scientific circle by claiming that the fossils of the caves were the bones of the rebel angels, possibly you may have a few doctors of medicine almost unable to appreciate the scientific criticism of the four Gospels.

But, as we have thus recognized this law of method as the fruit of our culture, we shall be able to see the interdependence of all these branches of knowledge. All our gains are helpful to each other. I might sum the vast history of science in a word—that it has taught us the harmony of law, not only in the correlation of natural forces, but of the moral and social forces of human life. But I look more especially at the studies which employ your profession, as they have shed such light on the marvelous secrets of the inner man. The cunning laws of cerebration; the wondrous rhythm that runs between the several powers of memory, feeling, will, and the sensitive nerve-centres; the dependence of thought on the supply of the chemical brain-food; the explanation of the riddles of our dream-life; the relation of our mental functions to the loss or decay of our organs; the phases of disease as affecting voluntary action—all these are as needful a study for the intellectual or the Christian thinker as for the naturalist. These researches have not only cured many mistakes of our psychology, but have given us sounder views of life and education. It is not too much to say that our theories of social and religious culture have been far too often affected by a partial view of our spiritual nature, which lost sight of its dependence on the body and the healthy laws of action. But while I gratefully acknowledge this debt, I hold that our scientific culture will, if faithful to its aim, lead us to a nobler knowledge of those truths that pass beyond a bald materialism. I

can only touch here upon this wide subject. If I were to seek an argument against the modern deniers of a Divine Maker and Providence, I should turn to science itself as furnishing its best ground. The result of our study of Nature, it is justly claimed, is only the knowledge of phenomena; but in this claim science has rid us forever of the notion of material substance; it has resolved all into one original, persistent Force; it has thus lifted matter into a domain above the physical, and by its own induction brought us back to the necessary truth, which we can only interpret by our own personal intelligence and will. If evolution, whatever its amazing chain of growth, is forced to admit that the principal world-stuff has in it the capacity of all the thinking, conscious, moral being begotten from it, evolution is but a vague name for the living action of a living God. And when I sum, again, our results as to the human organism, all our knowledge of the fitness of the cerebral mass and each fibre of the spinal net-work to the motions of the unseen life, so far from proving thought a function of the brain, or will a shock of the nerve-power, has only refined the body into the perfect vehicle of the indwelling spirit. Nothing is more satisfying to a believer in facts above Nature than that chapter on the "Substance of the Mind," where the apostle of English Positivism, Mr. Spencer, gives us as the outcome of his analysis, that when we talk of material or spiritual substances, it is indifferent whether "we express those in terms of these, or these of those;" yet, as thought cannot be dissected like the gray matter of the brain, it is sounder science to say that the living force is another than the physical fact.

But I cannot linger on these questions. Enough if I look forward in this light to the most harmonious results. We need not expect at once a reconciliation of all discords. Much must be done before that is reached. The clergyman has to learn fully that the Word of God is to be studied as the oracle of the great truths of man's spiritual history, not rashly made the rule of exact science. The naturalist must learn that there are facts of conscience and of human life more sacred than the guesses of his theory, which he must touch with reverent hands. Indeed, I have sometimes thought if the clergy could ramble with Mr. Huxley over the glaciers, and Mr. Huxley would take an excursion into the fields of Christian history, we should have better clerical sermons, and better "lay sermons." Science will work its own cure at last. It is not probable that there will be less prayer on account of Mr. Tyndall's "prayer-gauge," so long as it is the bidding of the heart of man. It is not probable, if, as a witty doctor has lately hinted, we measure the varied genius of Homer, Spenser, or Béranger, by the slower or quicker respiration, that we shall read the "Iliad" or "Faerie Queene" with less delight. It is not probable that all our discoveries of the ape period will kindle our interest so much as the history we remember far better of the struggles and divine triumphs

of the full-grown man. Let Science go on with its keenest analysis. It will return, when it is completed, to the living synthesis. If, with all our processes, we cannot manufacture a man, if even the mineral water we concoct is not quite the same as Nature brews in her laboratory, much more shall we give up the fruitless task of dissolving the ultimate facts of mind and life. I have been struck with a sentence of the late Mr. Mill, in his autobiography, where he speaks of a long stage of mental depression which destroyed his zeal for all his favorite studies. "I saw," he says, "that the habit of analysis tends to wear away the feelings. My education had failed to create these feelings in sufficient strength to resist this dissolving influence, while the whole course of my intellectual cultivation had made such analysis the inveterate habit of the mind. I was thus left stranded at the commencement of my voyage, with a well-equipped ship and a rudder, but no sail; without any desire for the ends I had been so carefully fitted to work for." That is the autobiography of our time, of its strength and of its weakness. Let such experience teach us the honest pursuit of science, but teach us also its limit. Our age will gather up the real gains of its knowledge. We shall have learned many of the laws of our being; we shall apply ourselves to a broader culture of the mind; we shall feel a more earnest interest in all aims for the improvement of the race. But we shall prize no less the treasures of letters and art bequeathed us by the past; the ideal truths which have employed the wise and good; and, above all, that Christian faith which has inspired the richest knowledge of mankind, and without which our best culture will be as dead as the fossils of a prehistoric cavern.

Such, gentlemen, is the result I anticipate for the next period of our scientific growth. Pardon me if I have given you too long or too dry an essay; but let me beg you to receive it as the conviction of one who feels a generous sympathy with all the real aims of his time. This is the best spirit of your noble profession. If you so pursue it, as honest interpreters of Nature and reverent worshipers of Him who is above Nature, you will make it a sacred ministry for not only physical knowledge, but for the service of God and man.

## THE DEEPER HARMONIES OF SCIENCE AND RELIGION.[1]

THERE are two very opposite parties among us at the present day, whose language is in one respect very strikingly similar. The Christian Church has from the beginning spoken with a certain contempt of learning. "The wisdom of the world," "oppositions of

[1] This article appeared in *Macmillan's Magazine* under the title of "Natural Religion."

science falsely so called," "to the Greeks foolishness;" these are the phrases of one of the earliest and highest of Christian authorities. In our own country the two most powerful of Christian movements, Puritanism and Evangelicalism, have been distinctly marked with this characteristic feature, although it might be possible to mention one or two learned Evangelicals and several learned Puritans. That there have been, and are, a vast number of men at the same time Christian and learned, does not affect the fact that Christianity holds itself aloof from and in a manner superior to learning. Such men, where their Christian feeling has been intense, have often spoken disparagingly of their own learning, as of a thing of little value, and have taken a pride in placing themselves on a level with the ignorant. If it is true that eloquent vindications of learning from the Christian point of view might be quoted, lofty assertions of the sympathy of Christianity for whatever is true and elevated, such assertions do not prove so much as is proved by the necessity of making them. If we admire them, it is rather because we love learning than because we love Christianity. We admire them as noble deviations from the Christian tradition, in a point where we have a misgiving that Christianity may be narrow. Yet this contempt for *learning* no Christian would admit to be equivalent to a contempt for *knowledge.* Knowledge, a certain kind of knowledge, Christians maintain to be the only thing worth having. Wealth, power, every thing that is counted desirable, they despise in comparison with a certain kind of knowledge. It is among these things comparatively despicable that they class what is commonly called learning. They despise it not *as* learning, but as learning comparatively worthless in quality, as being but a counterfeit of the true learning which it is happiness and salvation to possess.

Now, in this respect quite an opposite school hold the very same language. Scientific men resemble Christians, in treating with great contempt what goes by the name of learning and philosophy, in comparison with another sort of wisdom which they believe themselves to possess. Like Christians, they are no contemners of knowledge; on the contrary, in praise of knowledge they grow eloquent, and use language of scriptural elevation. "Wisdom is the principal thing, therefore get wisdom; and with all thy getting, get understanding." It is their unceasing cry that all good is to be expected from the increase of true knowledge; that the happiness, both of the race and individuals, depends upon the advance of real science, and the application of it to human life. Yet they have a contempt for learning, which is just as Christian in its tone as their love for knowledge. "Erudition" and "philosophy" are terms of contempt in their mouths. The first they consider to be, for the most part, a criminal waste of time; philosophy they denounce as consisting mainly of empty words, and offering solutions either imaginary or unintelligible of problems which are either imaginary or unintelligible themselves. In some scientific

men this feeling of contempt for learning is concealed; they will profess to admire scholarship and erudition, speaking of it as a graceful accomplishment; and it is only in unguarded moments that they betray their conviction that it is nothing more; others proclaim it loudly, and some even wish to bring public opinion to bear upon the matter, so as to prevent as an immorality the acquiring of useless knowledge.

Thus, the old religious school, and that new school whose convictions we see now gradually acquiring the character of a religion, agree in combining a passionate love for what they believe true knowledge, with a contempt for so-called learning and philosophy. The common enemy of both is what the one school calls, and the other might well call, "the wisdom of the world." But though agreeing so far, these two schools hate their common enemy much less than they hate each other. For each regards the "true wisdom" of the other as worse and more mischievous than the wisdom of the world which each rejects. To the scientific school the Christian γνῶσις is a mystical superstition, compared with which "learning and philosophy" are science itself. To the Christian, modern science is a darkness compared with which the science that St. Paul rejected might almost be called Christianity.

Nothing is so terrible as this clashing of opposite religions. Differences on important subjects are always painful, but the direct shock of contrary enthusiasms has something appalling about it. That one man's highest truth should be another man's deadliest falsehood; that one man should be ready to die in disinterested self-devotion for a cause which another man is equally ready to oppose at the sacrifice of his life; this is a horror which is none the less horrible because it has often been witnessed on this perplexed planet. But often it has been seen, long after the conflict was over, that there had been misapprehension; that the difference of opinion was not really any thing like so complete as it seemed. Nay, it has often happened that a later generation has seen the difference to be very small indeed, and has wondered that so much could have been made of it. In such cases the mind is relieved of that fancy of a radical discord in human nature. We see that self-devotions have not really clashed in such fell antagonism. We see that with self-devotion there may mix less noble feelings, and that the immitigable hostility of religious strife may be caused by a mixture of ardent conviction with some impulses less noble, with some that are blamable and some that are even ludicrous, with mere pugnacity, with the passion of gratifying self-importance, with the half-noble pleasure that there is in fighting, and the ignoble pleasure that there is in giving pain.

It would certainly be hard enough to show that the present strife between Christianity and science is one in which insignificant differences are magnified by the imagination of the combatants. The

question is nothing less than this, whether we are to regard the grave with assured hope, and the ties between human beings as indissoluble by death; or, on the other hand, to dismiss the thought of a future life as too doubtful to be worth considering, even if not absolutely chimerical. No reasoning can make such a difference into a small one. But even where the differences are so great, it may still be worth while to call attention to the points of agreement. In our penury of truth we ought to make the very utmost of our agreements. Let us rescue whatever we can from the waves of doubt; sailors thrown shipwrecked on a desert island must save what they can, not what they would. If there is some truth, however small, upon which all can agree, then there is some action upon which all can unite; and who can tell how much may be done by any thing so rare as absolute unanimity? Moreover, if we look closely, we shall always find our agreement to be more than we had expected. It seems as if men valued difference of opinion for its own sake. We seem not to care for any doctrine that is not controvertible. We talk with contempt of platitudes and truisms. Platitudes and truisms do not work up into interesting books; but, if our object is to accomplish something for human life, we shall scarcely find any truth serviceable that has not been rubbed into a truism, and scarcely any maxim that has not been worn into a platitude. But men seldom apply to truths this test of practice; they try them by the other test, which is the test of talk and debate. Thus it happens that ten points of agreement seem less important in most assemblies than one point of difference. Why is it men do not discover by experience the waste that is caused by this method? Either they must have a great deal of time on their hands, or else they have most unreasonable expectations from controversy. But I return to my point.

We are all familiar with the language used by Christians in disparagement of learning. God, they say, has revealed to men all that is essential for them to know. By the side of revealed knowledge what the human intellect can discover for itself is of little importance. If it seem to clash with revelation, it is mischievous; if not, it may be useful in a subordinate degree. But at the best it is contemptible by the side of the "one thing needful;" and the greatest discoverer that ever lived is a trifler compared with the most simple-minded Christian who has studied to fulfill the requirements of the gospel.

There are indeed a true erudition and a true philosophy, the subject of which is God's revelation itself. Scholars, profoundly read in the sources of theology, whether they be supposed to be the Bible or the Fathers of the Church; philosophers who have made the Christian revelation their basis, or have collected and elucidated the evidence of it—these are truly wise, and escape the censure of frivolity under which secular learning lies; but even these, illustrious and venerable

as they may be, will acknowledge that there is a wisdom beyond their own, which the humblest Christian may possess, the wisdom of simple belief and love.

We are less familiar as yet with the invectives of scientific men against what has long passed for learning and philosophy in the world. Different sections of the scientific school bring the accusation in different language. Yet the same feeling, the same strong and contemptuous conviction, pervades the whole school. What they reject and assail is, in two words, knowledge based on authority, and knowledge wanting an inductive basis.

That the utterances of great and famous philosophers are to be taken as truth; that in science, as in the civil law, the *responsa prudentum* have a binding force; has been accepted in some departments of knowledge up to the present day. Long after the authority of Aristotle had been shaken, new thinkers were allowed to occupy a similar place in some branches, and from Descartes to Hegel a sort of monarchical rule has prevailed in metaphysics. The scientific school tolerates nothing of this kind. Not that it refuses to reverence superior minds, not perhaps that it is altogether incapable of yielding to the temptation of trusting a particular authority for a while too much, or following a temporary fashion. But as a general rule it rejects as a superstition the notion that the most superior mind is at all infallible; it dissents without scruple from those whom it reverences most; and on the other hand the most eminent members of it encourage this freedom, are well pleased to be contradicted, and avoid assuming an oracular style as a mark of charlatanry. Such a *coup d'état* in philosophy as that of Auguste Comte is resolutely resisted, and the autocracy of Hegel comes to an end, not by the accession of a new monarch, but rather by the proclamation of a republic in German philosophy.

By the introduction of this new principle a large proportion of the doctrine current in the world is branded with the mark of spuriousness. In theology, metaphysics, moral philosophy, history, politics, the principle of authority has reigned hitherto with more or less exclusiveness. The repudiation of it is a revolution in those departments of knowledge. It converts whole libraries into waste-paper, silences controversies that have raged for ages, reduces to worthlessness the whole store of learning hived up in many capacious memories. It throws discredit at the same time upon the very name of erudition; not as such, for there is a kind of erudition much appreciated by the scientific school; but because erudition, as hitherto understood, has commonly gone along with, has in a great degree grown out of, an excessive reverence for the opinions of famous men. All that part of erudition, in particular, which is to knowledge what relic-worship is to religion, the laborious collection of minute facts that concern illustrious men, begins to seem

superstitious and childish when the general estimate of human wisdom so decidedly sinks.

But the more important change is in the extension of the Baconian method to the whole domain of philosophy. While one part of the "wisdom of the world" has been discredited as resting solely on authority, another large division of it is now rejected as resting on inductions insufficient or untrustworthy, and another as resting on groundless assumptions, disguised under the name of necessary truths, truths of the reason, truths given in consciousness, etc. The long habit of trying experiments, the vast experience which has been gained of the mistakes which may be made about matters of fact and of the infinite carelessness of the unscientific mind, have exposed to doubt whatever has been deduced in past ages from facts not recurrent or capable of being reproduced at will. The steady progress of discovery in the experimental sciences has stood out in contrast with the oscillating and unprogressive character of the sciences of mind. Moreover, in their process of extension the experimental sciences have constantly trenched on the domain which was supposed to lie definitively beyond their limit. Physiology has brought us close to mind, and the old distinction between matter and spirit begins to be slighted as a superstition. The old psychology also is assailed as not properly based on physiology. Moral philosophy does not escape. It, as well as the philosophy of law, has suffered through the influx of new knowledge about remote races of men. Duties and rights, which once appeared axiomatic, and inseparable from human nature, now appear the artificial products of special conditions. The very notion of duty itself is represented as such an artificial product.

All these new ideas gathering upon our minds produce a skepticism with regard to current philosophy which extends much further than the particular beliefs with which they seem to conflict. We have grown so accustomed to find so-called incontrovertible axioms resolve themselves into inveterate prejudices, that we have grown shy of all those facile generalities which captivated former ages. Those current abstractions which make up all the morality and all the philosophy of most people, have become suspicious and dangerous to us. Mind and matter, duties and rights, morality and expediency, honor and interest, virtue and vice, all these words, which seemed once to express elementary and certain realities, now strike us as just the words which, thrown into the scientific crucible, might dissolve at once. It is thus not merely philosophy which is discredited, but just that homely and popular wisdom by which common life is guided. This, too, it appears, instead of being the sterling product of plain experience, is the overflow of a spurious philosophy, the redundance of the uncontrolled speculations of thinkers who were unacquainted with scientific method.

This second change leads to self-distrust, as the first led to distrust of other men. As we learn not to take our truth at second-hand from other thinkers, so we learn that we must not take it, if the expression may be used, from ourselves. Truth is not what *we* think, any more than it is what famous men have thought. That which irresistibly strikes us as true, that which seems self-evident, that which commends itself to us, may nevertheless, we learn, not be true at all. It is not enough to judge for ourselves, to examine the facts independently. We must examine the facts according to a rigorous method, which has been elaborated by a long series of investigators, and without which neither candor nor impartiality would save us either from seeing wrong, or from receiving unsound evidence, or from generalizing too fast, or from allowing some delusive name to come between us and the reality. Distrust of others, distrust of ourselves—if the first of these two factors of the scientific spirit were separated from the second, the result would be mere self-conceit, mere irreverence. As it is, the scientific spirit is simply a jealous watchfulness against that tendency of human nature to read itself into the universe, which will show itself both in each individual and in the very greatest investigators, and which can only be controlled by rigorously adhering to a fixed process, and rigidly verifying the work of others by the same.

Knowledge, not scientifically obtained and verified, might very fitly be called by the name which Christianity uses. It might be called "human knowledge," or "the wisdom of the world." For the difference between it and genuine knowledge is just this, that it is adulterated by a human element. It is not the result of a contact between the universe and the naked human intelligence. The perceiving mind has mixed itself up with the thing perceived, and not merely in the way in which it always must, in the way which constitutes cognition, but in quite other and arbitrary ways, by wishes, by prejudices, by crotchets, by vanities. Such humanized views of the universe have a peculiar though cheap attractiveness. They naturally please the human mind, because, in fact, they were expressly contrived to do so. They adapt themselves readily to rhetoric and poetry, because, in fact, they *are* rhetoric and poetry in disguise. To reject them is to mortify human nature; it is an act of vigorous asceticism. It is to renounce the world as truly as the Christian does when he protests against fashionable vices. It is to reject a pleasant thing on the ground that it is insincere—that it is not, in fact, what it professes to be. The moral attitude of the man who does it is just such as Hebrew prophets assumed toward the flattering and lying court-prophets of their day; just such as Christianity itself assumed toward Pharisaism; just such as Luther and Knox assumed toward mediævalism; just such as the Puritans assumed toward prelacy. It is an attitude of indignant sincerity, an attitude marking an inward determination to face the truth of the universe, however disagreeable, and not to allow it to be adul-

terated and drugged, so as to suit our human feebleness. If we cannot produce from the authoritative documents of religion texts directly sanctioning it, this is because the particular problem was not presented in ancient times to the nation which gave us our religion. Those documents are full of passages expressing in poetic forms and in language suited to another age the spirit of modern science. Notably, the book of Job, not in occasional passages only, but as its main object and drift, contrasts the conventional, and, as it were, orthodox view of the universe, with the view which those obtain who are prepared to face its awfulness directly.

Thus the religious view and the scientific view of the universe, which are thought to be so opposite, agree in this important point. Both protest earnestly against human wisdom. Both wait for a message which is to come to them from without. Religion says, "Let man be silent, and listen when God speaks." Science says, "Let us interrogate Nature, and let us be sure that the answer we get is really Nature's, and not merely an echo of our own voice." Now, whether or not religion and science agree in what they recommend, it is evident that they agree in what they denounce. They agree in denouncing that pride of the human intellect which supposes it knows every thing, which is not passive enough in the presence of reality, but deceives itself with pompous words instead of things, and with flattering eloquence instead of sober truth.

Here, however, it will be said, the agreement between religion and science ends, and even this agreement is only apparent. Science protests against the idols or delusions of the human intellect, in order that it may substitute for them the reality of Nature; religion sacrifices all those idols to the greatest of them all, which is God. For what is God—so the argument runs—but an hypothesis, which religious men have mistaken for a demonstrated reality? And is it not precisely against such premature hypotheses that science most strenuously protests? That a Personal Will is the cause of the universe—this might stand very well as an hypothesis to work with, until facts should either confirm it, or force it to give way to another either different or at least modified. That this Personal Will is benevolent, and is shown to be so by the facts of the universe, which evince a providential care for man and other animals—this is just one of those plausibilities which passed muster before scientific method was understood—but modern science rejects it as unproved. Modern science holds that there may be design in the universe, but that to penetrate the design is, and probably always will be, beyond the power of the human understanding. That this Personal Will has on particular occasions revealed itself by breaking through the customary order of the universe, and performing what are called miracles—this is one of those legends of which histories were full, until a stricter view of evidence was introduced, and the modern critical spirit sifted thoroughly

the annals of the world. But if modern science be right in these opinions, the very notion of God is removed altogether from the domain of practical life. So long as God appeared certainly to exist, he necessarily eclipsed and reduced to insignificance all other existences. So long as it was held possible to discover his will and mind, all other inquiries might reasonably be pronounced frivolous. But all is changed as soon as we begin to regard his existence as a mere hypothesis, and his will as inscrutable and beyond the reach of the human understanding. Not only is all changed, but all is reversed. Instead of being the one important question, God's will now becomes the one *un*important question, because the one question which it is essentially impossible to answer. Whereas, before we might charge men with frivolity who neglected this inquiry for inquiries the most important in themselves, now we may pronounce the shallowest dilettant, the most laboriously idle antiquary, a solid and sensible man, compared to the theologian. They pursue, to be sure, very minute objects, but they do or may attain them; the theologian attempts an impossibility—he is like the child who tries to reach the beginning of the rainbow.

It would appear, then, that that which I have called "human wisdom," and which is the butt, at the same time, of theology and science, is so because it is a kind of middle party between two mortally hostile factions. It is like the Girondins between the Royalists and the Jacobins; both may oppose, and may even in a particular case combine to oppose it, and yet on that account they may not have the smallest sympathy with each other. And the middle party once crushed, there will follow no reconciliation, but a mortal contest between the extremes. Is this so or is it otherwise? The question is whether the statement given above of the theological view of the universe is exhaustive or not? Is it all summed up in the three propositions that a Personal Will is the cause of the universe, that that Will is perfectly benevolent, that that Will has sometimes interfered by miracles with the order of the universe? If these propositions exhaust it, and science throws discredit upon all of them, evidently theology and science are irreconcilable, and the contest between them must end in the destruction of one or the other.

It may be remarked, in the first place, that these propositions are not so much an abstract of theology as of the particular theology now current. That God is perfectly benevolent is a maxim of popular Christianity, and it may be found stated in the Bible. But it is not necessary to theology as such. Many nations have believed in gods of mixed or positively malignant character. Other nations have indeed ascribed to their deities all the admirable qualities they could conceive, but benevolence was not one of these. They have believed in gods that were beautiful, powerful, immortal, happy, but not benevolent. It may even be said that the Bible and Christianity itself have not uni-

formly represented God as perfectly benevolent. In the Old Testament he is described as just, but at the same time terrible and pitiless against the wicked; and at least one form of modern Christianity, Calvinism, takes a view of the Divine character which it is impossible to reconcile with infinite benevolence. Moreover, if almost all theologies have introduced what we should ascribe as miracle, yet it would be very incorrect to class many of them in this respect with that current view of Christianity, which represents God as demonstrating his existence by occasional interruptions of the order, otherwise invariable, of Nature. Probably, in the majority of theologies, no other law of Nature, except the will of God, is recognized; miracle, when it is introduced, is not regarded as breaking through any order; the very notion conveyed by the word supernatural is unacknowledged; miraculous occurrences are not distinguished from ordinary ones, except as being rarer, and not distinguished from rare occurrences at all. To an ancient Jew probably an earthquake and the staying of the sun on Gibeon were occurrences of precisely the same character and not distinguished as they are in our minds, the one as rare but natural, the other as supernatural and miraculous. All that was miraculous might have been removed from the creed of an ancient Jew without shaking his theology. Two out of the three propositions, then, are not necessary to the theological view of the universe. But surely the third is. Surely all theology implies that a Personal Will is the cause of the universe. I cannot admit even this. In the first place it is a very shallow view of theologies which represents them as having in all cases sprung from speculation about causes. Undoubtedly we can trace this speculation in our own religion. The phenomena of the world are accounted for very manifestly in the book of Genesis by the fiat of a Personal Will. But this is not at all an invariable character of theology. The *Deity of a thing* is often regarded in theologies not at all as the cause of it, but in quite another way, perhaps I might say as the *unity* of it. No one has ever supposed that the Greeks regarded Poseidon as the *cause* of the sea. Athena seems to have been suggested to them by the sky, but she is not the *cause* of the sky. And it would be easy to conceive a theology which did not occupy itself at all with causes, but which at the same time conceived the separate phenomena of the universe, or the universe itself altogether *personally*

May we, then, alter the proposition thus—instead of saying, It is characteristic of the theological view of the universe to suppose a personal will or wills to be the cause of all phenomena, may we say, Theology invariably conceives the universe under the form of personality, a personal will being assumed as either the cause or the law of phenomena? Even this would be to go too far. Personality is only known to us as belonging to human beings. Personality is properly the abstraction of the qualities common to man, woman and child. Of these one of the principal is what we call the will.

Now, the utmost that can be said is that theology has asserted an analogy more or less strong between the phenomena of Nature and human beings. Personality entire has never been attributed in any theology to deities. Personality, as we know it, involves mortality. Deities are always supposed immortal. Personality involves a body. The highest theologies have declared God to be incorporeal. We are brought back, then, to the will. Theologies attribute to deities a *will* like that of human beings. They do so; but again the highest theologies assert that the Divine Will is high above the human; that there is "no searching" of it; "that as the heaven is high above the earth, so are his ways than our ways, and his thoughts than our thoughts."

If the possibility of miracles were entirely given up, and the order of Nature decided to be as invariable as science inclines to consider it; if all the appearances of benevolent design in the universe were explained away, it might be true that the belief in God would cease to be consoling. Instead of being a spring of life and activity, it might—I am not now saying it would—become a depressing and overwhelming influence. And this, no doubt, is what people mean when they identify, as they commonly do, the belief in God with belief in an overruling Benevolence, and in the supernatural. They mean to say, not exactly that the belief in God *is* necessarily this, but that to be in any way useful or beneficial it must necessarily be this. But for my present purpose it is important to distinguish between the God in whom ordinary people at the present day believe, and a God of another character in whom they might conceivably believe. I desire to insist upon the point that when science speaks of God as a myth or an hypothesis, and declares the existence of God to be doubtful, and destined always to remain doubtful, it is speaking of a particular conception of God, of God conceived as benevolent, as outside of Nature, as personal, as the cause of phenomena. Do these attributes of benevolence, personality, etc., exhaust the idea of God? Are they—not merely the most important, the most consoling of his attributes, but—the only ones? By denying them do we cease not merely to be orthodox Christians, but to be theists?

Science opposes to God Nature. When it denies God it denies the existence of any power beyond or superior to Nature; and it may deny at the same time any thing like a *cause* of Nature. It believes in certain laws of coexistence and sequence in phenomena, and in denying God it means to deny that any thing further can be known. God and Nature, then, express ideas which are different in an important particular. But it is evident enough that these ideas are not the opposites that controversy would represent them to be. On the contrary, they coincide up to a certain point. Those who believe in Nature may deny God, but those who believe in God believe, as a matter of course, in Nature also. The belief in God includes the belief in

Nature, as the whole includes the part. Science would represent theology as disregarding Nature, as passing over those laws which govern the universe, and occupying itself solely with occasional suspensions of them, or with ulterior, inscrutable causes. But this account of theology is derived from a partial view of it. It is practically to some extent true of the theologies of recent times, which have been driven out of the domain of Nature by the rival and victorious method of physical science. But it is not true at all of the older theologies. They occupied themselves quite as much with laws as with causes; so far from being opposed to science, they were in fact themselves science in a rudimentary form; so far from neglecting the natural for the supernatural, they recognized no such distinction. The true object of theology at the beginning was to throw light upon natural laws; it used, no doubt, a crude method, and in some cases it attempted problems which modern science calls insoluble. Then, when a new method was introduced, theology stuck obstinately to its old one, and when the new method proved itself successful, theology gradually withdrew into those domains, where as yet the old method was not threatened, and might still reign without opposition. Thus it began to be supposed that law belonged to science, and suspension of law, or miracle, to theology; that the one was concerned with Nature, and the other with that which was above Nature. Gradually the name of God began to be associated with the supernatural, and scientific men began to say they had nothing to do with God, and theologians to find something alien to them in the word Nature.

Yet theology can never go further than this in repudiating Nature. It can never deny that Nature is an ordinance of God; it can never question that the laws of Nature are laws of God. It may indeed treat them as of secondary importance; it may consider that they reveal God in an aspect in which it is not most important that we should know him. But it cannot and does not deny that Nature, too, is a revelation of God; it ought not to deny that natural philosophy is a part of theology, that there is a theology which may be called natural, and which does not consist in a collection of the evidences of benevolent design in the universe, but in a true deduction of the laws which govern the universe, whatever those laws may be, and whatever they may seem to indicate concerning the character of God.

But, if, on the one hand, the study of Nature be one part of the study of God, is it not true, on the other, that he who believes only in Nature is a theist, and has a theology? Men slide easily from the most momentous controversies into the most contemptible logomachies. If we will look at things, and not merely at words, we shall soon see that the scientific man has a theology and a God, a most impressive theology, a most awful and glorious God. I say that man believes in a God who feels himself in the presence of a Power apart from and immeasurably above his own, a Power in the contemplation of which he

is absorbed, in the knowledge of which he finds safety and happiness. And such now is Nature to the scientific man. I do not now say that it is good or satisfying to worship such a God, but I say that no class of men since the world began have ever more truly believed in a God, or more ardently, or with more conviction, worshiped him. Comparing their religion in its fresh youth to the present confused forms of Christianity, I think a by-stander would say that though Christianity had in it something far higher and deeper and more ennobling, yet the average scientific man worships just at present a more awful, and, as it were, a greater Deity than the average Christian. In so many Christians the idea of God has been degraded by childish and little-minded teaching; the Eternal and the Infinite and the All-embracing has been represented as the head of the clerical interest, as a sort of clergyman, as a sort of school-master, as a sort of philanthropist. But the scientific man *knows* him to be eternal; in astronomy, in geology, he becomes familiar with the countless millenniums of his lifetime. The scientific man strains his mind actually to realize God's infinity. In the fixed stars he traces him, "distance inexpressible by numbers that have name." Meanwhile, to the theologian, infinity and eternity are very much of empty words when applied to the object of his worship. He does not realize them in actual facts and definite computations.

But it is not merely because he realizes a stupendous Power that I call the scientific man a theist. A true theist ought to recognize his Deity as giving him the law to which his life ought to be conformed. Now, here it is that the resemblance of modern science to theology comes out most manifestly. There is no stronger conviction in this age than the conviction of the scientific man, that all happiness depends upon the knowledge of the laws of Nature, and the careful adaptation of human life to them. Of this I have spoken before. Luther and Calvin were not more jealous of the Church tradition that had obscured the true word of God in the Scriptures than the modern man of science is of the metaphysics and conventional philosophy that have beguiled men away from Nature and her laws. They want to remodel all education, all preaching, so that the laws of Nature may become known to every man, and that every one may be in a condition to find his happiness in obeying them. They chafe at the notion of men studying any thing else. They behave toward those who do not know Nature with the same sort of impatient insolence with which a Christian behaved toward the worshipers of the emperor or a Mohammedan toward idolaters. As I sympathize very partially with the Mohammedan, and not quite perfectly with the early Christian, so I find the modern scientific zeal narrow and fanatical; but I recognize that it is zeal of the same kind as theirs—that is, that, like theirs, it is theological.

An infinite Power will inspire awe and an anxious desire to obey

its laws on the part of those who feel themselves dependent on it. But such awe and fear, it may be said, do not constitute worship; worship implies admiration, and something which may be called love. Now, it is true that the scientific man cannot feel for Nature such love as a pious mind may feel for the God of Christians. The highest love is inspired by love, or by justice and goodness, and of these qualities science as yet discerns little or nothing in Nature. But a very genuine love, though of a lower kind, is felt by the contemplator of Nature. Nature, if not morally good, is infinitely interesting, infinitely beautiful. He who studies it has continually the exquisite pleasure of discerning or half discerning and divining *laws;* regularities glimmer through an appearance of confusion; analogies between phenomena of a different order suggest themselves and set the imagination in motion; the mind is haunted with the sense of a vast unity not yet discoverable or namable. There is food for contemplation which never runs short; you are gazing at an object which is always growing clearer, and yet always, in the very act of growing clearer, presenting new mysteries. And this arresting and absorbing spectacle, so fascinating by its variety, is at the same time overwhelming by its greatness; so that those who have devoted their lives to the contemplation scarcely ever fail to testify to the endless delight it gives them, and also to the overpowering awe with which from time to time it surprises them.

There is one more feeling which a worshiper should have for his Deity, a sense of personal connection, and, as it were, relationship. The last verse of a hymn of praise is very appropriately this—"for this God is *our* God forever and ever; He will be our guide even unto death." This feeling, too, the worshiper of Nature has. He cannot separate himself from that which he contemplates. Though he has the power of gazing upon it as something outside himself, yet he knows himself to be a part of it. The same laws whose operations he watches in the universe he may study in his own body. Heat and light and gravitation govern himself as they govern plants and heavenly bodies. "In him," may the worshiper of this Deity say with intimate conviction, "in him we live and move and have our being." When men whose minds are possessed with a thought like this, and whose lives are devoted to such a contemplation, say, "As for God, we know nothing of him; science knows nothing of him; it is a name belonging to an extinct system of philosophy;" I think they are playing with words. By what name they call the object of their contemplation is in itself a matter of little importance. Whether they say God, or prefer to say Nature, the important thing is that their minds are filled with the sense of a Power to all appearance infinite and eternal, a Power to which their own being is inseparably connected, in the knowledge of whose ways alone are safety and well-being, in the contemplation of which they find a beatific vision.

Well! this God is also the God of Christians. That the God of Christians is something more does not affect this fact. Nature, according to all systems of Christian theology, is God's ordinance. Whether with science you stop short at Nature, or with theology believe in a God who is the author of Nature, in either case Nature is divine, for it is either God or the work of God. This whole domain is common to science and theology. When theology says, Let us give up the wisdom of men and listen to the voice of God, and when science says, Let us give up human authority and hollow *a priori* knowledge and listen to Nature, they are agreed to the whole extent of the narrower proposition, i. e., theology ought to admit all that science says, though science admits only a part of what theology says. Theology cannot say the laws of Nature are not divine; all it can say is, they are not the most important of the divine laws. Perhaps not, but they gain an importance from the fact that they are laws upon which all can agree. Making the largest allowance for discoveries, about which science may be too confident, there remains a vast mass of natural knowledge which no one questions. This to the Christian is so much knowledge about God, and he ought to rejoice quite as much as the man of science at the rigorous method by which it has been separated from the human prejudice and hasty ingenuity, and delusive rhetoric or poetry, which might have adulterated it. By this means we have been enabled to hear a voice which is unmistakably God's. And if it seems to be God speaking about matters not of the greatest importance, still perhaps it may be as well to listen. So much, at least, reverence seems to dictate; and, if it did not, the urgent necessity for more agreement on fundamental questions would dictate it imperiously.

This train of thought will be followed a little further in future numbers of this magazine.—*Macmillan's Magazine.*

## MODERN STREET-PAVEMENTS.

By ADOLF CLUSS, C. E.

THE most distinguished sanitarians of the age have established the fact that our modern cities are mostly so located that public health depends much less upon climate and position than upon rational conditions and modes of life. Enforced cleanliness, and the progress of sanitary works in cities, are followed by an enhanced vitality and elasticity of mind still more than by longevity of the inhabitants. Among sanitary works, improved pavements are classed along with sewerage, water-closets, and water-supply under pressure; since it is a prime condition of public hygiene that every

street and alley should drain as promptly and thoroughly as the houses erected on it. A proper observance of these maxims has materially contributed to the reduction of the annual death-rate of London within the last two centuries from forty-two to twenty-two per thousand, notwithstanding the unprecedented increase in the numbers and density of the population. An average decrease of thirteen per cent. in the death-rate has been traced directly to the influence of modern sanitary works, introduced into cities mostly during the last twenty years; and a thorough reform in pavements must give still more striking results.

The material for pavements is mostly decided upon by non-professional municipal authorities, and upon these an enlightened public opinion must exert a beneficial influence. A condensed review of the subject, in the light of history, technical science, hygiene, and finance, will help excite reflection, and to mature rational views, and will furnish a timely contribution to the literature of the day. Manufacturing industry, commerce, and railroads, those important motors of modern civilization, have combined to increase the number and size, and to concentrate the internal traffic of large cities, so that horses and vehicles have steadily increased, absolutely as well as in proportion to the population. Under the same influences an enormous wealth, formerly unknown, has been amassed in the cities, and whole streets have risen, lined by majestic buildings, in uninterrupted succession; while, even in the older or less pretentious streets, houses of a mere utilitarian character disappear, to make way for structures with an elevated standard of architecture. What at an earlier epoch was the proud privilege of the famous capitals of Italy, the exceptional luxury of their dwellings and mansions, is now to be found in most modern cities, though the effect be not as overpowering, on account of a want of harmony in the style.

Simultaneously with the higher wants resulting from greater wealth and closer contact, whole cities have been transformed from loose aggregates of irregularly-scattered houses into well-organized systems, all the elements of which, though serving individual purposes, are intimately connected by the complicated net-works of pipes supplying fresh water, discharging waste water and soil, and furnishing light during the night to the streets as well as to the houses, from cellar to roof; to which, perhaps, the inventive genius of the age may add, before long, the supply of heat for domestic necessities and personal comfort. In such a complex organism, the roadways and sidewalks are not merely spaces set apart for light, air, and traffic, but they are component parts of the wonderful machinery devoted to these purposes, and bear close relations to the dwellings which they separate and connect, and the restorative veins of which they cover as a protecting crust.

Of all these coöperating agencies, the least attention, until recent-

ly, was paid to the construction of roadways. Cobble-stones were resorted to for paving-purposes, since they were easily obtainable in the alluvial plains in which most modern cities are founded. They were succeeded by irregular quarried stones of such quality as was within easy reach; then by larger square blocks, mainly of trap-rock or granite, such as were thought necessary in streets with heavy traffic. But experience has proved that the jarring against them compelled the construction of heavier wagons, and that their peculiar smoothness by wear caused the horses to fall, and so this material was modified to uniform oblong blocks in narrow courses. These, after severe tests, have maintained a truer surface, have been found to offer a greater resistance against wear, to lessen the noise, and to decrease considerably the number of accidents to horses. They are called, in common with the former, *Belgian* blocks.

A most important sanitary feature, almost entirely neglected before the rapid concentration of population in the cities, now demanded attention. The cubical stone blocks are displaced under the prodigious traffic, the corners and edges are worn away, the surface gets to be irregular, the joints are widened. The filth of the streets gathers in ruts and joints, is recruited constantly by new accessions of urine, horse-dung, and silt, and, diluted by the rain, it ferments, and forms a putrescent organic mire, becoming in course of time a source of noxious miasmas. In hot and dry weather these nauseating deposits pass into the atmosphere in the form of unhealthy vapors, or, pulverized and drifted by the wind, cause inconvenience and poison our lungs. Indeed, in repairing old pavements, a black layer of ground, saturated with sulphuretted hydrogen, is found below the stone blocks, and bears witness to the infection of the subsoil by the soakage of contaminated water. Prof. Tyndall has established by experiments that a large proportion of the particles of dust in the rooms of London houses is of organic origin, and other experiments have demonstrated that horse-manure, in a state of decomposition, is a permanent ingredient.

Vapors still more noxious than those from the road-bed of the streets rise from the gutters, the subsoil of which is saturated to a considerable depth by more concentrated matter of the described composition, and also from the surface of alleys on which are the houses of great numbers of people of limited means. Crowds of dirty children, whose tender lungs breathe the air immediately over this miasmatic soil, here contract constitutional predispositions, which doom them to a languishing and miserable life, and render them an easy prey to epidemics. This infection of the subsoil has been prevented, with a certain degree of success, by foundations of concrete. There is still another feature of stone pavements in the heart of cities, which affects the inner man more than the physical frame, viz., the rattling and noise, under heavy traffic, accompanied, in alluvial soil, by vibrations

of the adjoining buildings. People with strong nerves, and accustomed to this rattle from early youth, may to some extent become hardened, but they will never get to be insensible to it; any indisposition is aggravated by the nuisance, and for recovery they hurry to the country. People with weak nerves, especially delicately-organized women, suffer great and permanent injury to the health. Nothing but the constant torment has partially dulled us to this evil. If cities had never been afflicted with this noise, and if, in a competition with other more suitable materials, stone pavements were adopted, a storm of opposition would soon sweep them out of existence again. Some of these difficulties have been obviated by using smaller and harder stones; but the objection to the improved Belgian pavement in general use, on account of the germs of disease stored in the wide joints and under the blocks, still remains.

To do away with the objection to stone pavements, efforts were made to introduce into cities the macadamized roads, which had proved eminently successful as country roads; these efforts have proved signal failures, though, when properly made, and in thoroughly good order, macadamized roads approach perhaps more nearly the desiderata than most others that have been tested, and are among the pleasantest and safest roadways in ordinary use. But the constant outlay for repairs, the difficulty of traction over them when recently laid, and considerations of hygiene and comfort, are such serious objections that they are gradually being displaced by other kinds of pavement. Whoever is doomed to live on a macadamized street needs no description of its horrors. These streets have justly been nicknamed crushing-mills for granite. Six hundred and fifty thousand tons of granite are annually pulverized on the streets of London, of which but one-sixth is due to the wear of paving-stones, the rest is attributable to the macadamized roads. This dust has to be scrubbed, washed, and brushed ever so often from clothes, furniture, stairs, and floors, before it is finally removed through silt-basins and carts, or sewers and river.

A little rain transforms these streets into broad slush-beds from which every thing within reach is bespattered by the hurrying wheels of vehicles. Ladies with modern garments cannot cross them, and whoever visits along such streets must leave a certain quantity of dirt on floors and carpets. But mud is not the worst affliction, for this mash, consisting of stone-dust, sand, and horse-dung, is transformed into dust by dry and hot weather, is whirled up by the rolling wheels, or, still worse, is drifted by wind, rendering the air unfit for respiration, penetrating into the tender, sensitive cavities of the lungs, settling on skin, hair, and clothes; suffocating the flowers and green leaves of plants along parked streets; forbidding the opening of windows, fouling the glass, and driving through the joints of the sash; lodging in curtains and blinds, spoiling the costly products of industry and man-

ufacture in the show-windows, and haunting the anxious housewife in kitchen, pantry, and cellar. The devoted denizen finds but a partial protection against the shocking nuisance, when he mixes this dust with an abundance of water—by sprinkling the street.

A modification of the macadam is the *Telford road;* it consists of a bed of firmly-wedged quarry-stones, with an even surface as a foundation, upon which a layer of larger and a layer of smaller broken stone, mostly trap-rock, are spread, each being rolled by horse and steam rollers. Upon the well-compacted surface a binding of screened gravel is applied, moistened and rolled in, so as to present one solid mass, which, while hard and durable, yet retains some elasticity. This variety, superior for country-roads, though still open to the vital objection of dust, is equal in price to the costly modern city pavements, and therefore has found but a limited application within city limits—for instance, on the Boulevards of New York.

Wood pavements which, at one time, were much used in Britain, especially in London, and also in New York in 1835 and 1836, but were abandoned for weighty reasons, and especially on account of their rapid decay, were revived in the rising cities of the great West, notably Chicago, where stone was scarce, lumber was cheap, and a porous, sandy subsoil retarded the decay of the perishable wood-blocks by dry rot from below, as happens on retentive soil. These wood pavements, smooth, noiseless, and advantageous for traction, were rather hastily adopted by municipal committees or boards in Eastern cities, where the conditions were different, and where decomposition commenced after two or three years' use. The heavy profits made induced a desperate fight in their favor by interested parties, a renewed effort in behalf of "treated" wood gave them a respite and a second harvest before final disuse, which was accelerated, however, by the overwhelming complaints of the offensive and unhealthy effluvia emitted from them; so that, in a sanitary point of view, the advantage of the absence of stone-dust was much overbalanced by the decomposition of the material itself.

The wood-blocks during treatment have been mostly impregnated, by pneumatic processes, with chloride of zinc, sulphate of iron, or oily, creosotic substances; and, though railroad-sleepers, telegraph-poles, etc., have been satisfactorily preserved through these agencies, such methods have failed, for various causes, to render an equivalent for the expenses incurred in treating the paving-blocks. But the patience of the people is not yet exhausted, and, in Northwestern cities, a new and costly revival is being arranged by the substitution of sulphate of copper for impregnation, a substance used in France, under M. Boucherie's patent, for thirty-five years past. The District of Columbia has been preëminently the experimental ground for treated wood pavements. An investment of about $5,000,000, a sum far in excess of that in any other city of the globe, has been made there within

little more than three years in wood pavements, nearly all treated; many of them are now in an advanced state of decay, and, from the degree of preservation after two or three years' use on suburban streets with hardly any wear, one cannot approve of any of the processes applied, since none of them have effectively neutralized the destructive local agencies, or made up for inferiority in the quality of lumber used. Square, polygonal, wedge-shaped, and undressed round blocks, of pine, spruce, and juniper wood, set in rows, interlocking or parted by interstices, upon sand, board, or concrete foundations, were tried, so that all classes of patentees had chances to trot out their hobbies and gratify their passion to serve the community. Though this is an interesting study, we cannot in this place do full justice by entering into details.

The idea of ranking expensive wood pavements, treated and untreated, as valuable standard pavements, where more substantial materials can be procured at the same or lower prices, will, before long, hardly more than elicit a smile from the critical expert.

In this state of the problem, it may be considered as a new epoch in city-life that the increased facilities of commercial intercourse, by cheapening the cost of transportation, have brought a relief within reach, namely, asphaltum for roadways. The nature of asphaltum is frequently misunderstood, because the mineralogist, in speaking of asphaltum, has reference to the brittle bitumen usually found in Nature, while the civil-engineer designates by mineral asphaltum a porous limestone, in combination with tough bitumen. This limestone was primarily impregnated by volcanic action with petroleum, which appears to have oxidized within the structure of the stone by the slow action of many centuries. Thus both ingredients have been united so thoroughly in the asphaltum that neither heat nor water, nor the combined action of both, in causing decay, can render it hard and brittle by abstracting the tough bitumen from the limestone. It is not strange that the efforts artificially to imitate this intimate union have often produced materials with quite different powers of resistance against the various destructive agencies and vicissitudes of climates; and that the lack of durability—not to speak of numerous dead failures in various compounds of raw or treated coal-tar and coal-pitch with coal-ashes, saw-dust, cinders, sand, gravel, etc., commonly called concrete pavements, which have reduced moderately dirty streets, under the influence of the heat of summer, to vast sticky quagmires—has formed a serious drawback to the introduction of better material, and especially the well-tested native asphaltum, which will probably, in our climate, many times outlast the best artificial composition yet known, as it has done in other countries. The admixtures and distillations from coal-tar and pitch have been amply relied upon as the base for artificial concrete, on account of a supposed resemblance to the native asphaltum. This idea, however, is

not sustained by modern scientific tests. Seen in thin layers under the microscope, the bitumen, the color of which is otherwise a deep black, shows a transparent yellowish mass, while coal-pitch is visible as a mass of coherent black points on an orange-colored ground. This investigation of the mastic relied upon suffices to explain in the one case the quality of toughness and binding power, and in the other that of brittleness.

Efforts are now being made to produce concrete pavements based on mixtures of silicate of soda with Portland cement. The latter, along with native asphaltum, is undoubtedly the most important modern building-material, but it has its separate province, and lacks just those qualities of the native asphaltum which are so highly appreciated for paving-purposes. It will hardly ever be successful in the long-run when encroaching on the sphere of the competing material which it has fairly outrivaled as a cement for brickwork and masonry, for which, in ancient times, asphaltum enjoyed a just celebrity, as attested by the remnants of the walls of Babylon and Nineveh. This class of pavement has been tested carefully in France with the well-known *béton coignet* and has failed. While the artificial mixtures soon require expensive surfacing, the native asphaltum when taken up for piping, or otherwise, after many years' wear, may be used again by simply heating and treating it as at first. In this aspect it bears such a relation to the artificial concretes as a copper roof does to a common tin roof.

Nature has unfortunately produced this valuable mineral deposit in but very few cases, and it has not yet been found in America, for the so-called Trinidad asphaltum consists mainly of bituminous scoriæ, cemented together with vitrified sand and earth; and even the more esteemed Cuban asphalts contain from 27 to 34 per cent. of earthy substances. The deposits from Tyrimont-Seyssel, on the banks of the Rhone, in France, were the first to be used for pavements. But, as they contain only from 6 to 8 per cent. of bitumen, the powdered rock was found rather too dry, and therefore was superseded by the extensive deposits of the Val de Travers, the most important valley debouching from the Jurassic mountains of Switzerland into the Lake of Neufchâtel. These, with steady march, have conquered the markets of the world. The deposits known as Neufchâtel rock contain, with a constancy not found anywhere else, from 11 to 12 per cent. of bitumen—a most favorable proportion. Besides, they have absolutely greater toughness as a result of their degree of oxidation. They were formerly extensively used as a mastic for sidewalks, and form an excellent material for carriage-ways. They have been used since 1854 in Paris, and since 1868 in the principal thoroughfares of London and other European capitals.

The success of this bituminous rock pavement is by no means due to the lucky hit of one individual; it is the legitimate result of

the persistent efforts of some of the best engineers of the age, by which all obstacles have been gradually overcome. The first trials were made with mastic, consisting of the powdered rock melted with mineral tar as a flux, and mixed with sea-grit which was laid upon an ordinary concrete foundation; they were followed by experiments with mastic, cast into blocks at the workshops, and laid with wide joints, which were filled in again with heated mastic. Next we hear of tests with broken asphaltic rock, rammed in a cold state upon a macadam foundation. And finally these intelligent labors were crowned by the splendid improvement of the compressed rock pavement, for which the rock, reduced by heat to powder and rammed and rolled while yet hot, into a homogeneous, tight covering, is laid upon a perfectly dry ordinary concrete foundation composed of crushed stone and cement. This simple improvement virtually adapts the old principle of a barn-floor of rammed clay, for thrashing, to the requirements of the open air, by making it water-proof. In place of the mastic, which attains consistency, by the congelation of the melted mass, without application of pressure, this "merely compressed body, in which the molecules of bitumen and limestone are soldered together by heat and ramming," obviates all tendency toward brittleness, without in the least interfering with the advantages of perfect homogeneity or water-proof qualities. It stands to reason that the mastic, which, notwithstanding its mixture with grit, is more or less pitchy, would be surpassed in elasticity and pliability by a merely kneaded mass. These pavements are reported to have withstood the extreme heat of Bombay, Hindostan, as well as the greatest known cold. Not affording any escape to the terrestrial heat through joints, they are kept warm and open from below in most cases when block-pavements present an icy surface. Their smooth, seamless face, being almost entirely free from abrasion by attrition or atmospheric action, meets the mechanical and hygienic objections to block-pavements, both of stone and wood, as well as of macadamized roads.

The asphaltum pavement is clean and fit for traffic a few hours after being laid, while new or repaved stone roadways must be covered for months with heavy layers of sand, to be drifted by the breeze in dry weather and added to the mud in rainy spells. Repairs can be made to the asphaltum pavement in dry days of a cold winter, while with stone pavements any defects must be endured until spring. Besides the sanitary advantages, the saving in temper, clothes, shoes, and furniture, is not to be overlooked. The popularity of this pavement in the two largest cities of Europe, where, with immense traffic and most extensive experience on the relative value of pavements, the demands on the municipal authorities are inexorable, serves as a proof that smoothness of surface does not cause any danger with this material. Being elastic but not soft in summer, and hard but not brittle in winter, it possesses with a slight yield the power of readjustment in

a high degree, so that horses and drivers ever seek it, if it is "laid intelligently by practised hands, with a low crown" or flat profile.

A low crown is practicable because there are no surface-obstacles to drainage. It is also needful to prevent horses from falling on any spaces with a heavy decline toward the gutter. What is essential for the transverse profile of these streets is no less essential for their longitudinal profile: they must have easy grades—say a pitch of less than two per cent.—since the momentum of inertia of the masses in motion enters the problem. The smooth surface intensifies the downward motion of the wheels while decreasing the friction of the hoofs of the horse, which furnishes the power of resistance against the downward motion of the vehicle, or serves for affixing the power necessary to move the vehicle up-hill. With these precautions relief is afforded to the horse, this faithful companion of man, which, being dumb, is so often brutally ill-treated and abused.

It would lead too far to enlarge upon the numerous official experiments and observations made in Paris and London by which, though made under circumstances most unfavorable for the new pavements, the proportion of accidents to horses and vehicles has been shown to be considerably less on the asphalt than on stone pavements, except in the rare case of a muddy street during wet weather. Ordinary care can achieve much in that direction. When driving on to an isolated asphaltum road, to which, in wet weather, mud has been dragged from adjoining streets of old construction, the change ought to be managed by checking the horses and gradually returning to full speed. As, by degrees, the regeneration of the streets becomes general, this temporary precaution will become unnecessary. Allusion to these minor details was deemed *à propos*, since the human mind is so constituted that little is generally thought of accidents of daily occurrence, while we are apt to be severe and even unjust against novel improvements, which, of course, in the beginning present more or less difficulties to be overcome under actual tests. The same man who unconcernedly sees a horse fall on a stone-paved street, or blames the driver, and even the horse itself, regardless of the pavement, might be loud with complaints or fears about the falling of a horse if traveling on a road of new construction.

During the careful examinations as to the merits of the new pavement, questions were raised regarding its fire-proof qualities. Indeed, we hear that, during the siege of Paris by the Germans, the population, visited by cold, and short of fuel, tore up the asphaltum roads to enjoy fires fed therewith. But, on the other hand, it is also recorded that, during the eventful time of the Commune, when incendiarism was frequent and ingenious, these pavements never caught or spread the fire, the proportion of the combustibles to the incombustibles in the asphaltum of the streets being too small to feed the fire. The matter-of-fact people of London were not satisfied with any thing

less than severe direct tests: their engineers had to pile wood upon the asphaltum pavement, pour petroleum over it, and light it. When the fire burned most lively, and there were plenty of red-hot coals underneath, the space was cleared and nothing but little flames were noticed, which immediately died out. G. A. Shaw, the head of the London fire-brigade, who attended, declared expressly his faith in the harmless nature of the pavements during conflagrations. There is no doubt that asphaltum pavements may occasionally fail, but, when they do, this is attributable not to the material, if unadulterated, but rather to the method of its application, which requires skilled workmen, whose eyes and hands are quick and directed by an intelligent mind. The District of Columbia has about $1,750,000 invested in concrete and asphalt pavements, including the various patented mixtures and the natural asphaltic rock, and, though a certain degree of success has been attained under some of the patents, this does not appear to be uniform and under control of the engineers; nearly all show clear evidences of disintegration, and are periodically in need of repairs or resurfacing, which latter means virtually a failure of the patented process, while the pavements of natural rock rather improve by wear, and their first cost, in depreciated securities, was but $4.25 per square yard against $3.20 for the patented admixtures.

After these explanations, based on personal observations, as well as on the results of the experience of the leading engineers in this branch, the conclusion may well be drawn that asphaltum roads are destined to be the city pavements of the future—a destiny which is determined by the progressive spirit of the age, and which cannot be retarded for any length of time; it involves the interests of all, both high and low. If the most elegant and most frequented streets have the privilege to lead the van, it ought to be appreciated that the luxurious life of the higher classes depends upon the strength and activity of the children of the industrious classes as much as upon the toil of the farm-hand who, fortunately enough, is enabled to recruit his strength in open fields; hence, justice should be done likewise to the demands of health for the poorer classes, who, in consequence of the highly improper laying out of the cities, as bequests of by-gone generations, are frequently doomed to live in alleys and lanes, and these should be drawn into the vortex of a reform which, when accomplished, will gladden the humanitarian, whose head and heart are in sympathy with civilization in its noblest aspect.

WASHINGTON, *March* 26, 1875.

# DISCOURSE ON THE DEATH OF LYELL.

By Dean STANLEY.

DEAN STANLEY selected for his sermon the words of the second verse of the first chapter of Genesis: "The earth was without form, and void; and darkness was upon the face of the deep. And the spirit of God moved upon the face of the waters." The sermon was, in fact, a discourse on the religious aspect of geology.

The words of the text, the dean said, have a sense wider than the mere literal transcript. They express the transition from that gulf which the Greeks called chaos, to the order of the universe which a modern philosopher described under the head of "cosmos." The words in the original, which portray the formless void of the earth, convey most precisely the image of warring elements, while the words used for the moving of the Divine Spirit on the face of the waters express the gentle brooding, as it were, of a bird of peace. The language, however poetic, childlike, parabolical, and unscientific, impresses upon us the principle which applies, in both the moral and in the material world, that the law of the divine operation is the gradual, peaceful, progressive development of discord into harmony, confusion into order, darkness into light.

It chanced that within the short month of February, by a most unusual coincidence of mortality, twice had the gates of the abbey been opened to pay the last honors to two men widely apart in all else, but alike in the share they took in unfolding and exemplifying this divine law, the one the acknowledged chief of the English musicians of our time, the other the acknowledged head of those who, whether here or elsewhere, have devoted their talents to the study of the history of our mother earth. Of all the branches of art and letters, none more reveals the hidden capacities of the human soul, or the fearful and wonderful structure of the human frame, than the slow process through which, from the most barbarous sounds, the spirit which brooded over the harp of David, and inspired the genius of Beethoven and Mendelssohn, has gained its majesty and glory.

This passing allusion to a great musician, this indication of the latent capacities for spiritual emotion brought out by abstract and inanimate things, elements seemingly without form and void, was no unfitting prelude to the consideration of the study of Nature, of which he who has just gone was so bright an example.

It is well known that, when the study of geology first arose, it was involved in interminable schemes of reconciliation with the letter of Scripture. There were and are two modes of reconciliation, which have each totally and deservedly failed. The one attempts to wrest the words of the Bible from their real meaning, and force them to

speak the language of science; and the other attempts to falsify science to meet the supposed requirements of the Bible. The "seventy," finding that the hare was described as chewing the cud, inserted the word "not;" and on the other hand, the Jesuits, in editing Newton's "Principia," announced in the preface that they were constrained to treat the theory of gravitation as a fictitious hypothesis, else it would conflict with the decrees of the popes against the motion of the earth.

But there is another reconciliation of a higher kind, or rather not a reconciliation, but an acknowledgment of the affinity and identity which exist between the spirit of science and the spirit of the Bible. First, there is a likeness of the general spirit of the Bible truths; and, secondly, there is a likeness in the methods. For instance, the geological truth which our illustrious student was the chief instrument in clearly setting forth and establishing was the doctrine, wrought out by careful, cautious inquiry in all parts of the world, that the frame of this earth was gradually brought into its present condition not by sudden and violent convulsions, but by the slow and silent action of the same causes which we see now, but operating through a long succession of ages beyond the memory and imagination of man. There need be no question whether this doctrine agrees or not with the letter of the Bible. We do not expect it should. For, had there been no such scientific conclusions, we now know perfectly well, from our increased insight into the nature and origin of the early biblical records, that they were not and could not be literal, prosaic, matter-of-fact descriptions of the beginning of the world, of which, as of its end, no man knoweth or can conceive except by figures or parables. It is now clear to all students of the Bible that the first and second chapters of Genesis contain two narratives of the creation side by side, differing from each other in almost every particular of time and place and order. It is now known that the vast epochs demanded by scientific observation are incompatible both with the 6,000 years of the Mosaic chronology and the six days of the Mosaic Creation. No one now infers from the Bible that the earth is fixed, that it cannot be moved, that the sun does literally go forth as a bridegroom from his chamber, or that the stars sung with an audible voice in the dawn of the creation. But when we rise to the spirit, the ideal, the general drift and purpose of the biblical accounts, we find ourselves in an atmosphere of moral elevation which meets the highest requirements philosophy can make.

The discoveries of geology are found to fill up the old religious truths with a new life, and to derive from them in turn a hallowing glory. When the historian of our planet points out that the successive layers of the earth's surface were formed by such agencies as we know of now, by the constant action of wind and wave, of floating ice and rolling stones—that there were not separate centres of creation, but one primeval law which formed and governed all created things—what is this but the echo of those voices which of old de-

clared that in the beginning the heaven and earth were created, not by a thousand conflicting deities, but by one supreme and indivisible, and that He hath given all things a law that shall not be broken? And we may compare the vast infinities of time and space, that long ascending order, that gradual progress demanded by geology, with the words in the sublime ninetieth psalm, read at the burial service: "A thousand years in thy sight are but as yesterday which is past, and as a watch in the night." Surely the view of the gradual preparation of the earth for mankind is grander than that which makes him coeval with the beasts which perish, and we ought to honor the archæologist who by unhasting, unresting research revealed in all their length and breadth the genealogy and the antiquity of man and of his habitation. He rent the veil and showed the long vista of the temple of the Most High, not made with hands—"*Apparet domus intus, et atria longa patescunt.*" Not the limitation but the amplification of the idea of God is the result of the labor of such a student, and not the descent but the ascent of man is the outcome of his speculations. If, as he used to say, we have in our bones the chill of the contracted view of the past in which till now we were brought up, the enlargement which he effected of that view ought to give a warmth, a fire to our soul of souls, in proportion as we feel that we are indeed not the creatures of yesterday, but the heirs of the ages and worlds that have perished in the making of us.

As to the likeness of the general spirit of the method of science to that of the Bible, the Bible is a model to the student in its slow but increasing purpose of revelation, through sundry times and divers manners, warning each succeeding age to have its eyes open and every member of the human race to be the disciple—that is, "scholar," as the founder of Christianity called his followers. To invest the pursuit of truth with the sanctity of a religious duty is the true reconciliation of religion and science. Such a union has been the special glory of the great school of English geologists, and the two pioneers of the science at the time when it had to fight its way against prejudice, ignorance, and apathy, were both honored dignitaries of the English Church; and now within these walls there rests beneath the monument of Woodward one who was the friend of Sedgwick and the pupil of Buckland. He followed truth with a sanctified zeal, a childlike humility. For discovering, confirming, rectifying his conclusions, there was no journey he would not undertake. From early youth to extreme old age it was to him a religious duty fearlessly to correct all his own mistakes, and he was always ready to receive from others and reproduce that which he had not in himself. In his mind science and religion were indivisible. The freedom of religious inquiry in the national Church, the cause of humanity in the world at large, were to him as dear as though they were his own personal and peculiar concern. There is unusual solemnity in the thought of his passage into the eternal world, on which, as in a shadow or

mirror, he had so long meditated, in those long ages of which he was, as it were, the first discoverer. The "lofty and melancholy strain," the ninetieth Psalm, which old tradition ascribes to Moses, the man of God, whether it be or not the funeral hymn of the great lawgiver, well represents the feeling of one grown gray with vast experience, who at the close of his earthly journeyings contrasts the fleeting generations of man with the granite forms of the mountains at the feet of which he has wandered, and contrasts those mountains and man alike with Him who existed before, beyond, and above them all. It sums up with peculiar force the inner life of the Christian philosopher who concluded his chief work with the contrast between the finite powers of man and the attributes of an infinite God, and who felt persuaded that, after all the discoveries on earth or sea or sky, the religious sentiment remained the greatest and most indestructible instinct of the human race.

## THE PHYSIOLOGY OF AUTHORSHIP.

By R. E. FRANCILLON.

THERE is a botanical theory that a flower is nothing more than a leaf in which full development has been arrested. It is more beautiful than the leaf by reason, not of its perfection, but of its imperfection. Even so the leaf is a degenerate twig and the fruit a degenerate flower: so that productiveness comes from the loss of vital strength, and not, as would be assumed at first sight, from its increase. This is not, I believe, the orthodox scientific doctrine, but it is plausible enough to suggest an analogy. The history of a plant, according to the theory of degeneration, is strikingly like the pedigree of literary and artistic genius, according to any of the hundred definitions of that indefinite word. So far as known facts combine into a probable law, a creative intellect is never generated spontaneously. Like dukes and princes, men of imaginative genius have ancestors between themselves and Adam. *Bon chat chasse de race.* The lives of the mothers of great men form an important branch of biographical literature: and it is usual, even in the paternal line, to find traces of hereditary taste or talent tending toward original production. The mute, inglorious Milton finds a glorious tongue in his great-grandson: the great statesman is the heir of the village Hampden. The theory, though more than merely probable, is by its nature incapable of exhaustive proof: but instances are notorious enough to found thereon a reasonable assumption that family talent precedes individual genius even if the tendency has never made itself conspicuous, or, like the gout, has passed over a generation or two here and there. But, on the other hand, it is yet more certain that genius, like

the blossom with its fruit, closes while it crowns the family tree. The man of talent is the ancestor of the man of genius, but the man of genius is the ancestor either of nobodies or of nobody. Descendants of great authors, painters, and musicians, who lived two or three generations ago, are hardly to be found. While the families of great soldiers and statesmen swarm, there is scarcely a man in Europe who can boast of a great poet or other artist in the direct line of his pedigree: probably there is not even one who can boast of two such forefathers. The rough stem runs into the leaf, the leaf to the flower, and the flower to the fruit of good work, or—to seed. To pursue the analogy to its end, the full beauty and productiveness of imaginative genius correspond to the effect of decaying vitality.

Analogy, built upon an unscientific metaphor, is of course no argument: but it is a fair explanatory illustration of a theory that rests upon surer ground for its foundation. That the creative imagination or any other mental gift so far resembles disease as to require non-natural conditions for its exercise is not the popular doctrine. The well-known and often-quoted couplet about the near alliance of great wit to madness is directly opposed to the far more pleasant belief in sound minds in sound bodies as the most favorable condition for the production of the best work of all kinds. The tone of hero-worshipers themselves is, to deplore eccentric indulgences as weaknesses of genius rather than to recognize in them the artificial atmosphere necessary for production and creation. The popular doctrine is thoroughly wholesome, because it is taught by the many for the many, and to teach otherwise, in a broad way, would risk the popular confusion of genius with its accidents. But all safe, wholesome, popular doctrines have an unfortunate tendency to turn men at large into a great flock of sheep—infinitely better worth owning than a herd of red deer, but proportionately less full of individual character. The history of how imaginative work is done reads very like a deliberate and apparently insane effort to keep up the action of brain-fever by artificial stimulus, as if creative genius were literally an unsound habit of mind requiring an unsound habit of body—*mens insana in corpore insano.* Balzac, who had the disease of creative genius in its most outrageous form, "preached to us," says Théophile Gautier, "the strangest hygiene ever propounded among laymen. If we desired to hand our names down to posterity as authors, it was indispensable that we should immure ourselves absolutely for two or three years: that we should drink nothing but water and only eat soaked beans, like Protogenes: that we should go to bed at sunset and rise at midnight, to work hard till morning: that we should spend the whole day in revising, amending, extending, pruning, perfecting, and polishing our night's work, in correcting proofs or taking notes, or in other necessary study." If the author happened to be in love, he was only to see the lady of his heart for one half-hour a year: but he

might write to her for the cold-blooded reason that letter-writing improves the style. Not only did Balzac preach this austere doctrine, but he practised it as nearly as he could without ceasing altogether to be a man and a Frenchman. Léon Gozlan's account of the daily life of the author of the "Comédie Humaine" has often been quoted. He began his day with dinner at six in the afternoon, at which, while he fed his friends generously, he himself ate little besides fruit and drank nothing but water. At seven o'clock he wished his friends good-night and went to bed. At midnight he rose and worked—till dinner-time the next day: and so the world went round. George Sand calls him, "Drunk on water, intemperate in work, and sober in all other passions." Jules Janin asks, "Where has M. de Balzac gained his knowledge of woman—he, the anchorite?" Love and death came to him hand-in-hand: so that he might be taken as an example of the extreme result of imaginative work obtained by the extreme avoidance of artificial stimulus, and therefore as a fatal exception to the general theory, were it not for one little habit of his which, though a trifle in itself, is enough to bring his genius within the pale of the law. When he sat down to his desk, his servant, who regarded a man that abstained even from tobacco as scarcely human, used to place coffee within reach, and upon this he worked till his full brain would drive his starved and almost sleepless body into such self-forgetfulness that he often found himself at daybreak bareheaded and in dressing-gown and slippers in the Place du Carrousel, not knowing how he came there, and miles away from home. Now, coffee acts upon some temperaments like laudanum upon others, and many of the manners and customs of Balzac were those of a confirmed opium-eater. He had the same strange illusions, the same extravagant ideas, the same incapacity for distinguishing, with regard to outward things, between the possible and the impossible, the false and the true. His midnight wanderings, his facility for projecting himself into personalities utterly unlike his own, belong to the experiences of the "English Opium-Eater." On this assumption, the exaggerated abstinence of Balzac is less like an attempt to free the soul from the fetters of the flesh than a preparation for the fuller effect of a stimulus that instinctive experience had recommended. In any case his intemperate temperance is the reverse of the conditions in which wholesome unimaginative work can possibly be carried on.

Byron affords a similar, though of course less consistent, illustration of a tendency to put himself out of working condition in order to work the better. "At Disdati," says Moore, "his life was passed in the same regular round of habits into which he naturally fell." These habits included very late hours and semi-starvation, assisted by smoking cigars and chewing tobacco, and by green tea in the evening without milk or sugar. Like Balzac, he avoided meat and wine, and so gave less natural brain-food room for more active play. Schiller

was a night-worker and a coffee-drinker, and used to work on champagne. Not only so, but he used an artificial stimulus altogether peculiar to himself: he found it impossible, according to the well-known anecdote, to work except in a room filled with the scent of rotten apples, which he kept in a drawer of his writing-table, in order to keep up his necessary mental atmosphere. Shelley's practice of continually munching bread while composing is not a mere piece of trivial gossip when taken in connection with more striking and intelligible attempts to ruin the digestion by way of exciting the brain, and when it is remembered that his delicate and almost feminine organization might require far less to throw it off the balance than naturally stronger frames. At all events, it seems to point to the same instinctive craving for abnormal aids to work when the imagination is called upon—as if it were not intended that the creative power should be a function of the natural man. Of course there is no need to suppose that the stimulus is always or even often adopted with the deliberation of the actor, who used to sup on underdone pork-chops to inspire himself with the mood proper to tragedy. Nor need the stimulus be of a kind to produce intoxication, in the vulgar sense of the word. So long as it puts the body into a non-natural condition, in the way pointed out by individual instinct, it seems that the physical conditions of imaginative work are fulfilled.

Unfortunately for any complete treatment of the question, a sufficient body of data is not easily gathered. Great artists, in all fields of work, are notoriously shy of publishing their processes, even when they themselves know what their processes are. It is, however, always legitimate to argue from the known to the probable; and if it can be gathered that all great imaginative work, whenever the process is known, has been accompanied with some abnormal habit, however slight, it is fair enough to assume that the relation of cause and effect has something to do with the matter, and that some such habit may be suspected where processes are not known. There are, however, two great imaginative authors of the very first rank whom believers in the pleasant doctrine that the highest and freest work can be done under the healthiest conditions of fresh air, early hours, daylight, and temperance—which does not mean abstinence—have always claimed for their own. One of these is Goethe. He and Balzac are at precisely opposite poles in their way of working. Here is the account of Goethe's days at Weimar, according to Mr. G. H. Lewes: He rose at seven. Till eleven he worked without interruption. A cup of chocolate was then brought, and he worked on again till one. At two he dined. "His appetite was immense. Even on the days when he complained of not being hungry he ate much more than most men. . . . He sat a long while over his wine, chatting gayly, for he never dined alone. . . . He was fond of wine, and drank daily his two or three bottles." There was no dessert—Balzac's principal meal—nor

coffee. Then he went to the theatre, where a glass of punch was brought him at six, or else he received friends at home. By ten o'clock he was in bed, where he slept soundly. "Like Thorwaldsen, he had a talent for sleeping." No man of business or dictionary-maker could make a more healthy arrangement of his hours. The five or six hours of regular morning work, which left the rest of the day open for society and recreation, the early habits, the full allowance of sleep, and the rational use of food, are in glaring contrast to Balzac's short and broken slumbers, his night-work, and his bodily starvation. But he who imagined "Faust" is not to be so easily let off from his share in illustrating a rule. There is no need to quarrel with Mr. Lewes for going out of his way to prove that Goethe was not necessarily a toper because he liked wine and had a good head. Though a great deal of wine was no doubt essential to his general working power, it was in his case rather a tonic than an immediate stimulant, because it came after instead of during work-hours. But this is significant of the same result, only in a different way. Goethe differed from almost every great poet in not doing his greatest work at a white heat; and not only so, but he differed also in constantly balancing his reasoning against his creative faculties. I doubt very much if those long mornings of early work were often spent in the fever of creation. He was a physiologist, a botanist, a critic; and the longer he lived he became more and more of a *savant*, if not less and less of a poet. His imagination was most fertile before he settled down into these regular ways, but not before he settled down into a full appreciation of wine. Balzac would write the draft of a whole novel at a sitting, and then develop it on the margins of proofs, revises, and re-revises. Goethe acted as if, while art is long, life were long also. Till the contrary is proved, I must consistently hold that Goethe was the philosopher before dinnert-ime, and the poet in the theatre, or during those long after-dinner-hours, over his two or three bottles of wine. That these later hours were often spent socially proves nothing one way or the other. Some men need such active influences as their form of mental stimulus. Alfieri found or made his ideas while listening to music or galloping on horseback. Instances are common in every-day life of men who cannot think to good purpose when shut up in a room with a pen, and who find their best inspiration in wandering about the streets and hearing what they want in the rattle of cabs and the seething of life around them, like the scholar of Padua, whose conditions of work are given by Montaigne as a curiosity. "I lately found one of the most learned men in France . . . studying in the corner of a room, cut off by a screen, surrounded by a lot of riotous servants. He told me—and Seneca says much the same himself—that he worked all the better for this uproar, as though, overpowered by noise, he was obliged to withdraw all the more closely into himself for contemplation, while the storm of voices drove his thoughts inward. When at Padua he

had lodged so long over the clattering of the traffic and the tumult of the streets, that he had been trained not only to be indifferent to noise, but even to require it for the prosecution of his studies." So we learn from Mr. Forster that "method in every thing was Dickens's peculiarity, and between breakfast and luncheon, with rare exceptions, was his time of work. But his daily walks were less of rule than of enjoyment and necessity. In the midst of his writing they were indispensable, and especially, as it has often been shown, at night." When he had work on hand he walked all over the town, furiously and in all weathers, to the injury of his health. And his walks, be it observed, were frequently what Balzac's always were—at night; so that in the matter of hours he must be taken as having conformed in some important respects to Balzac's hygiene. Now, Goethe was also an essentially out-of-doors man by nature—not one to let his pen do his imagining for him. He was no slave of the ink-bottle as some are, who cannot think without the feather of a goose in their hands, by way of a sometimes appropriate talisman. There is a well-known passage in one of the Roman Elegies to the effect that inspiration is to be sought more directly than within the four walls of a study, and that the rhythm of the hexameter is not best drummed with the fingers on a wooden table. And if it is true, as he tells, that "youth is drunkenness without wine," it seems to follow, according to his experience, that those two or three bottles of wine are not altogether needless as an aid to inspiration when youth is gone by.

The fellow-instance of imaginative work triumphantly carried on under the most admirable healthy conditions is that of Scott. He used to finish the principal part of his day's work before breakfast, and, even when busiest, seldom worked as late as noon. And the end of that apparently most admirably healthy working-life we also know. "Ivanhoe" and "The Bride of Lammermoor" were dictated under the terrible stimulus of physical pain which wrung groans from him between the words. The very two novels wherein the creative power of the arch-master of romance shows itself most strongly were composed in the midst of literal birth-throes. It was then he made that grimmest of all bad puns—"When his audible suffering filled every pause, 'Nay, Willie,'" addressing Laidlaw, who wrote for him and implored him to rest, "'only see that the doors are fast. I would fain keep all the cry as well as all the wool to ourselves; but as to giving over work that can only be done when I am in woolen.'" So far from affording any argument to the contrary, the history of the years during which his hand was losing its cunning seems to illustrate the penalty of trying to reconcile two irreconcilable things—the exercise of the imagination to its fullest extent, and the observance of conditions that are too healthy to nourish a fever. *À propos* of his review of Ritson's "Caledonian Annals," he himself says, "No one that has not labored as I have done on imaginary topics can judge of

the comfort afforded by walking on all-fours and being grave and dull." There spoke the man who habitually and without artificial help drew upon his imagination at the hours when instinct has told others they should be employing not their fancy but their reason. The privilege of being healthily dull before breakfast must have been an intense relief to one who compelled himself to do unhealthy or abnormal work without the congenial help of abnormal conditions. Herder, in like manner, is accused by De Quincey, in direct terms, of having broken down prematurely *because* he "led a life of most exemplary temperance. . . . Surely if he had been a drunkard or an opium-eater, he might have contrived to weather the point of sixty years." This is putting things pretty strongly, but it is said of a man of great imaginative power by a man of great imaginative power, and may therefore be taken as the opinion of an expert all the more honest because he is prejudiced. A need must be strongly felt to be expressed with such daring contempt for popular axioms. At the same time "the German Coleridge" did not manage so very badly, seeing that he worked hard till sixty, and he allowed himself as much coffee as his exceptionally delicate nervous system would stand; so that in reality he seems to conform to the general rule by example rather than by way of exception. Scott is a far better type of the exception that approves the rule. Genius has been defined in as many different ways as there have been people who have tried to define it. But perhaps the most suggestive I have ever heard is the attempt to destroy an exceptionally strong constitution for the gratification of a mental tendency—the *physique* of an elephant, as I heard it roughly put, and the conduct of a slave-driver who is his own slave. There must be the exceptionally strong constitution to bear an abnormal strain and the effort by every means to do more than Nature when kindly treated will allow. The true working-life of Scott, who helped Nature by no artificial means, lasted for no more than twelve years from the publication of "Waverley" till the year in which his genius was put into harness; so that, of the two men, Scott and Balzac, who both began a literary life at nearly the same age, and were both remarkable for splendid constitutions, the man who lived abnormally beat the man who lived healthily by full eight years of good work, and kept his imagination in full vigor to the end.

That night and not morning is most appropriate to imaginative work is supported by a general consent among those who have followed instinct in this matter. Upon this question, which can scarcely be called vexed, Charles Lamb is the classical authority. "No true poem ever owed its birth to the sun's light. The mild internal light, that reveals the fine shapings of poetry, like fires on the domestic hearth, goes out in the sunshine. Milton's morning-hymn in paradise, we would hold a good wager, was penned at midnight, and Taylor's rich description of a sunrise smells decidedly of the taper." "This

view of evening and candle-light," to quote his commentator, De Quincey, once more, "as involved in the full delight of literature," may seem no more than a pleasant extravaganza, and no doubt it is in the nature of such gayeties to travel a little into exaggeration; but substantially it is certain that Lamb's sincere feelings pointed habitually in the direction here indicated. His literary studies, whether taking the color of tasks or diversions, courted the aid of evening, which by means of physical weariness produces a more luxurious state of repose than belongs to the labor-hours of day; they courted the aid of lamp-light, which, as Lord Bacon remarked, gives a gorgeousness to human pomps and pleasures such as would be vainly sought from the homeliness of daylight." Those words "physical weariness," if they do not contain the whole philosophy of the matter, are very near it, and are at all events more to the point than the quotation from Lord Bacon. They almost exactly define that non-natural condition of the body which, on other grounds, appears to be proper to the non-natural exercise of the mind. It will be remembered that Balzac recommended the night for the artist's work, the day for the author's drudgery. Southey, who knew how to work and how to get the best and the most out of himself as well as anybody who ever put pen to paper, and who pursued the same daily routine throughout his whole literary life, performed his tasks in the following order: From breakfast till dinner, history, transcription for the press, and, in general, all the work that Scott calls "walking on all fours." From dinner till tea, reading, letter-writing, the newspapers, and frequently a *siesta*—he, also, was an heroic sleeper, and slept whenever he had the chance. After tea, poetry, or whatever else his fancy chose—whatever work called upon the creative power. It is true that he went to bed regularly at half-past ten, so that his actual consumption of midnight oil was not extravagant. But such of it as he did consume was taken as a stimulant for the purely imaginative part of his work, when the labor that required no stimulant was over and done. Blake was a painter by day and a poet by night; he often got out of bed at midnight and wrote for hours, following by instinct the deliberate practice of less impulsive workers. Now, bodily weariness is simply bodily indolence induced artificially; its production by hard walking, hard riding, hard living, or hard study, looks like an instinctive effort on the part of energetic men to put themselves for the time and for a purpose into the chronically unhealthy condition of naturally indolent men. Indolence, that is to say chronic fatigue, appears to be the natural habit of imaginative brains. It is a commonplace to note that men of fertile fancy, as a class, have been notorious for their horror of the work of formulating their ideas even by the toil of thought, much more by passing them through the crucible of the ink-bottle. In many cases they have needed the very active stimulant of hunger. The *cacoëthes scribendi* is a disease common, not to imaginative, but to imitative minds. Probably no hewer

of wood or drawer of water undergoes a tithe of the toil of those whose work is reputed play, but is, in fact, a battle, every moment, between the flesh and the spirit. Campbell, who at the age of sixty-one could drudge at an unimaginative work for fourteen hours a day like a galley-slave, "and yet," as he says in one of his letters, "be as cheerful as a child," speaks in a much less industrious tone of the work which alone was congenial to him: "The truth is, I am not writing poetry but projecting it, and that keeps me more idle and abstracted than you can conceive. I pass hours thinking about what I am to compose. The actual time employed in composition is but a fraction of the time lost in setting about it." "At Glasgow," we read of him even when a young man, "he seldom exercised his gift except when roused into action either by the prospect of gaining a prize or by some stirring incident." Campbell, if not a great man, was a typical worker. Johnson—who, whatever may be thought of his imaginative powers, was another type—struck off his *Ramblers* and *Idlers* at a heat when the summons of the press forbade his indolence to put off his work another moment; he did not give himself even a minute to read over his papers before they went to the printers. He would not have written "Rasselas" except for the necessity of paying for his mother's funeral; and yet he was a laborious worker where the imagination was not concerned. The elder Dumas had to forbid himself, by an effort of will, to leave his desk before a certain number of pages were written, in order to get any work done at all. Victor Hugo is said to have locked up his clothes while writing "Notre-Dame," so that he might not escape from it till the last word was written. In such cases the so-called "pleasures of imagination" look singularly like the pains of stone-breaking. The hardest part of the lot of genius, I suspect, has been not the emotional troubles popularly—and with absurd exaggeration—ascribed to it, but a disgust for labor during the activity of the fancy, and the necessity for labor when it is most disgusting. And, as it is not in human nature to endure suffering willingly, the mood in which such labor is possible calls for artificial conditions by which it can be rendered endurable.

The passing mention of Blake indirectly suggests an objection. Nature has thought fit to place an insuperable bar between painters and night-work: and yet the work of the painter is as imaginative in character as that of the poet, while painters have shown no tendency, as a class, to break down under the strain. Artists in form have not often followed the example of Michael Angelo, who stuck a candle in a lump of clay, and the lump of clay on his head, and chiseled till morning. But then writing is the exercise of the imagination, including conception as well as execution; painting is the record of previous imagination, and so belongs to the daylight, even according to Balzac's rule. Skill, intelligence, the eye and the hand, which work best under natural and healthy conditions, have to bear the

strain. Because his hand and mind work by day, it does not follow that the painter's fancy is not a night-bird—only, happily, it is not called upon to labor in its dreaming hours. Musicians, who might be expected to demand the conditions of imaginative literature in a tenfold degree, have, in fact, breathed as common air the stimulating and unhealthy atmosphere that authors only enter when they need it. Musical genius is, so to speak, a self-supporting fever, that finds in every sort of exciting stimulus not its artificial but its natural and healthy atmosphere. Exceptions, like John Sebastian Bach, prove the notoriety of the rule by the stress which is laid upon them. The manners and customs of great artists in sound tend to support the general rule concerning all imaginative work to an infinite extent, but it would be unfair to argue from those who breathe poison for their native air to those who merely use poison in order to escape from the common air of the unimaginative world.

It is notorious that creative genius is essentially of the masculine gender. Women are the imaginative sex, but the work, which Nature seems to have distinctly allotted to them, has been done by men. This really strange phenomenon is not due to the fact that women have written comparatively little, because, if it were, the little imaginative work they have done would have been great in quality, and would surpass in quantity the other work they have done. But it has not been great in quality compared with that of men, and, compared with the rest of their own work, has been infinitesimally small. No woman ever wrote a great drama; not one of the world's great poems came from a woman's hand. In their own domain of fiction women have been, and occasionally are, great realists, great portrait-painters, great masters of style, great psychologists—but not great inventors, and very seldom inventors at all. Probably everybody will be able to name off-hand one or two exceptions to what looks like a very dogmatic and sweeping piece of criticism—and probably everybody will name exactly the same one or two. Nobody dreams of looking for absolutely great imaginative work, in any branch of art, from a woman; and, when by chance it comes, the admiration it excites is multiplied by wonder. People say, "See what a woman can do"—not "See what women can do." In music, the typically imaginative art, wherein they have had a free and open career, it is legitimately dogmatic to deny them any place at all. Seeing, therefore, that the natural imagination of women is comparatively barren while the ordinary unimaginativeness of men is absolutely fertile, it is impossible to doubt that the way of work has something to do with the matter. And if examples tend to prove that creative genius among men instinctively works under artificial and unhealthy conditions of body, while work wherein the imagination is not tasked is for the most part carried on under the calmest and healthiest conditions, it would follow that women at large fail to produce great

creative work by reason of their good working qualities—because they do not in general use artificial stimulants and irregular modes of life to help their brains to wear out their bodies. They keep themselves broad awake in order to dream! They seek to do imaginative work, and take as models the lives of men who do unimaginative work—that is to say, precisely the opposite routine to that of men by whom imaginative work is done. These prove negatively what the examples of creative genius prove positively. If scholars toil late into the early hours, it is to continue their day's work, not to begin it. It is interest that chains them to the desk at midnight, not impulse that calls them there. All philosophers have not always been sober men; but they have taken their indulgences as refreshments and recreations—as interruptions to work, and not as its necessary accompaniments. If Balzac's may be taken as the type of the artist's life, Kant's may be taken as the type of the student's. The habits of both are equally well known. Kant also gave a daily dinner-party; but when his guests were gone he took a walk in the country instead of seeking broken slumbers in a state of hunger. He came home at twilight, and read from candle-light till bedtime at ten. He rose punctually at five, and, over one cup of tea and part of a pipe, laid out his plan of work for the day. At seven he lectured, and wrote till dinner-time at about one. The regularity of his life was automatic. It was that of Balzac save in fulfilling all the accepted conditions of health—early rising, early lying down, moderate daily work, nightly rest, regular exercise, and a diet regulated with the care not of a lunatic but of a physician. A cup of tea and half a pipe in the morning cannot be looked upon as stimulants to a man in such perfect health as Kant always enjoyed; and, if they can be, let it be observed that it was while engaged with these he thought about his work—it was his hour for what Campbell called his "*fuming* meditations." He certainly used no other stimulant to work, in the common sense of the word; but even he illustrates, in another point, the need of the mind for artificial conditions, however slight they may be, when engaged in dreaming. During the blind-man's holiday between his walk and candle-light he sat down to think in twilight fashion; and, while thus engaged, he always placed himself so that his eyes might fall on a certain old tower. This old tower became so necessary to his thoughts that, when some poplar-trees grew up and hid it from his window, he found himself unable to think at all, until, at his earnest request, the trees were cropped and the tower brought into sight again. Kant's old tower recalls Buffon's incapability of thinking to good purpose except in full dress and with his hair in such elaborate order that, by way of external stimulus to his brain, he had a hair-dresser to interrupt his work twice, or, when very busy, thrice a day. It is curious to note the touch of kindred between the imaginative *savant* Buffon and the learned artist Haydn, who could not work

except in court-dress, and who used to declare that, if, when he sat down to his instrument, he had forgotten to put on a certain ring, he could not summon a single idea. How he managed to summon ideas before Frederick II. had given him the said ring we are not informed. But even these trivial instances of caprice help to suggest that, when the fancy is called upon, the ordinary conditions of straightforward work must be considered at an end. Fancy dictates the terms on which she condescends to appear. Of Dickens we are told that "some quaint little bronze figures on his desk were as much needed for the easy flow of his writing as blue ink or quill pens."

But, unhappily, the terms dictated by creative fancy have not been and are not always so innocent as blue ink, coffee, late hours, or rotten apples. A true and exhaustive history of how great imaginative work has been done would be too sad a chronicle, and would be good for nothing but to recall biographical memories that are better forgotten. No doubt most readers will be able to supply from memory instances enough to judge for themselves how far the well-known examples here given exemplify and account for the connection of creative genius with a tendency to chronic suicide. And if the necessity of this connection be admitted, then the question arises, "How far is any man justified or not justified in adopting in intellectual matters the doctrine that the end justifies the means? If he feels—and biography speaks vainly if he is held to be mistaken in feeling—that the work for which Nature intended him must be left undone unless he deliberately elects to ruin his health, to become an awful warning to the white sheep of the social sheepfold and a stumbling-block to would-be imitators, which is he to choose?" All the branches of the question, all its most trifling illustrations, lead to that broad issue which has never yet been boldly faced or fairly answered. The strange manners and customs of men of genius have often enough been defended as unfortunate weaknesses by their apologists: it seems to me they ought either to be condemned as unworthy of men of sense and will, or else boldly asserted as the necessary instruments of the work that owes its birth to them—as the artificial means of producing strength out of weakness which a man who lives for his work *ought* to use. If creative genius is really an unhealthy condition, it must require unhealthy methods to produce and sustain its action. It is not the healthy oyster that breeds the pearl. Nor is this a dangerous theory. The oyster does not deliberately produce in itself the disease of pearl-bearing, nor can any man—it need hardly be added—give himself genius by adopting and abusing the artificial means that enable genius to work when it is already there. The disease suggests its appropriate conditions: the conditions clearly cannot bring about the disease. The morality of the whole question, and its application to any particular case, must be settled by everybody for himself; but a story of a hurdle-race at Gadshill, told in Mr. Forster's life of Dick-

ens, contains in a homely way the summing up of its philosophy. "Among other oddities we had a hurdle-race for strangers. One man—he came in second—ran a hundred and twenty yards and leaped over ten hurdles in twenty seconds, *with a pipe in his mouth and smoking it all the time.* 'If it hadn't been for the pipe,' I said to him at the winning-post, 'you would have been first.' 'I beg your pardon, sir,' he answered, 'but *if it hadn't been for my pipe* I should have been *nowhere.*'"—*Gentleman's Magazine.*

## SKETCH OF DR. WILLIAM WHEWELL.

DR. WILLIAM WHEWELL stands highest in the literary world as the historian of science. His "History of the Inductive Sciences" is not a mere bald narration of the facts and details of scientific progress, but is a philosophical treatment of the subject, which shows the growth and advancement of principles or general truths. It is, in fact, an elaborate historical review of the processes of generalization, such as had never before been attempted. This work stands eminent among the scientific contributions of the past age, both on account of its historic erudition and its trustworthy representation of the broad inductions of modern scientific inquiry. It is a permanent work of reference in every scientific library; and the extent to which it has influenced the philosophical mind of the age is well illustrated by the acknowledgment of John Stuart Mill: that, if Whewell had not written the "History of the Inductive Sciences," the "Logic, Ratiocinative and Inductive," might never have appeared.

Dr. WHEWELL was born in Lancaster, May 24, 1794. His father was a joiner, and intended to have his son follow his trade. But while at school he showed such a remarkable talent for mathematics, together with evidences of more than ordinary ability in other branches, that it was decided to send him to Cambridge. He entered Trinity College, as Freshman, in 1813, at the age of nineteen. The following year he distinguished himself by winning the English Poetical Prize. He was graduated B. A. in 1816, with the honors of second wrangler in the Mathematical Tripos, was elected a Fellow, and soon afterward Tutor of Trinity College. He rapidly earned a reputation as a successful teacher, both in the class-room and as "coach," or private tutor.

He applied himself to mathematics and vigorously went to work to bring about a radical reform in the methods of teaching the physical sciences in England. In 1819 he published his first work, "An Elementary Treatise on Mechanics," designed for the use of students of the university. In 1820 he was elected a Fellow of the Royal Society, and we now find him contributing to the "Transactions" of

learned and scientific societies, and to scientific journals, papers on the tides, heat, electricity, and magnetism; and to the literary journals and reviews miscellaneous papers on subjects literary, historical, and metaphysical. In 1828 he was appointed Professor of Mineralogy in the university. In order to perfect his knowledge of that branch of natural science, he visited Germany and spent some time at the celebrated mining-schools of Freiburg and Vienna. He resigned his mineralogical professorship in 1833; published his treatises on "Statics," "Mechanics," and "Dynamics," and brought out his first great work, entitled "Astronomy and General Physics considered in their Relations to Natural Theology." In this work Dr. Whewell breaks connection with the traditions of the experimental school, and abandons Bacon and Locke, to range himself on the side of Kant, to whose philosophy he had become a convert while in Germany. He also endeavored, during this time, to make his countrymen acquainted with German literature and art, of which he was a warm admirer. He translated several gems of German literature, such as Goethe's "Hermann und Dorothea," and "The Professor's Wife," of Auerbach, and published "Notes on the Architecture of German Churches," which met with great success in England. Among other works of less importance published soon after, his "Thoughts on the Study of Mathematics as Part of a Liberal Education," and, particularly, his "Mechanical Euclid," gained considerable note. In 1837 he published his "History of the Inductive Sciences from the Earliest to the Present Times."

Dr. Whewell's thinking now seems to enter upon the road of philosophy. During this same year he published "Four Sermons on the Foundation of Morals," and in the following year (1838) he was appointed Professor of Moral Philosophy in the university. From this time forward he occupied himself almost wholly with moral questions. In 1840 he published a sequel to, or commentary on, his "History of the Inductive Sciences" under the title of "The Philosophy of the Inductive Sciences," which was afterward enlarged and published as three separate works under the titles of "History of Scientific Ideas," "Novum Organon Renovatum," and "On the Philosophy of Discovery." We may add to these a fourth, "Indications of the Creator," consisting of extracts bearing upon theology, from the "History" and "Philosophy of the Inductive Sciences." In 1841 he was appointed Master of Trinity, and was President of the British Association at its meeting in Plymouth. The same year he also put out another mathematical work, entitled the "Mechanics of Engineering." In 1845 he published his "Elements of Morality, including Polity," "Lectures on Systematic Morality," "On Liberal Education in General, and with Particular Reference to the Leading Studies of the University of Cambridge." The following year he issued another mathematical work on "Conic Sections; their Principal Properties proved Geometrically." In 1852 he published "Lectures on the History of Moral Philosophy in Eng-

land," and soon afterward, among others, a translation of Grotius's "Rights in Peace and War," a translation of Plato's "Dialogues," and, anonymously, a work entitled "The Plurality of Worlds," in which he argued that none of the planets, except the earth, are inhabited. This book had a great popularity, and excited much discussion. In 1855 he became Vice-Chancellor of the university, and retired from the professorship of Moral Philosophy, remaining, however, Master of Trinity. Among the last of his works was the editing, in 1861, of the mathematical works of Dr. Isaac Barrow, Master of Trinity in 1672. Dr. Whewell died May 5, 1866, from the effects of injuries received in a fall while riding on horseback. He was one of the most distinguished men that Trinity College has produced, and one of the best of its masters. He was a munificent benefactor to the college, to which he added one new court during his life, and at his death bequeathed his large fortune to the building of another, and to the founding of a professorship of International Law. Dr. Whewell was a large, strong, erect man, of the Johnsonian type, with a red face and a loud voice, an effective preacher, a vigorous controversialist, and a man of extensive and varied attainments, which were always at ready command. His memory was remarkable, but it was rather special, and took chiefly the direction of his studies. He could remember all about books and their contents with the greatest accuracy, but could not recollect the names of the Fellows of his own college. This was of course often wrongly interpreted; and very naturally so, it must be confessed, for Dr. Whewell's manner was marked by no little assumption of superiority. He was naturally aristocratic in feeling, and his pompous bearing among the college officials gave him the reputation of being arrogant. Still, he understood his own strength, and was not without excuse for a considerable degree of self-regard. A story is told of him which illustrates both his varied knowledge and his personal relations to his brother Fellows: He used frequently to so overwhelm the company at the Fellows' table with his learning, that a conspiracy was at length formed to put him down. A number of them, on one occasion, crammed up on Chinese music, from scattered articles in old reviews, which they supposed he would not be acquainted with, and then made the state of music among the Chinese the subject of a seemingly casual conversation at dinner. They were highly gratified with the apparent result; for, contrary to his usual custom, Dr. Whewell remained silent. When, however, they had nearly talked themselves out, he remarked: "I was imperfectly and to some extent incorrectly informed regarding Chinese music when I wrote the articles from which you have drawn your information." The conspiracy was a failure; the Fellows were disgusted, and the dignified doctor remained acknowledged master of the situation.

# CORRESPONDENCE.

## TO WHAT EXTENT IS EVOLUTION VISIBLE?

*To the Editor of the Popular Science Monthly:*

"It is less unphilosophical to suppose that each species has been evolved from a predecessor by a modification of its parts, than that it has suddenly started into existence out of nothing. Nor is there much weight in the remark that no man has ever witnessed such a transformation taking place."—(Draper, "History of the Conflict between Religion and Science," p. 192. "International Scientific Series," No. 12.)

There stands, in a window of my wife's sitting-room, a potted slip of geranium. To-day, I heard her remark, "I can see that this grows now, every day." In what sense is this true? By remembering its size and condition of yesterday, and comparing it with its present dimensions and conditions, an increase and change are demonstrable. It certainly has grown. But, if we were to sit down at sunrise and watch unceasingly until sunset, or by lamplight continue the vigil until sunrise again, we would in all this time have seen no enlargement of the main stem—no unfolding of a leaf-bud; still, both these changes have taken place within twenty-four hours, and, of course, in full view.

Is it not true in the same way, but far less rapidly, that the changes in animal life are constantly occurring—so gradually, that we cannot mark and measure the progress, but, like the plant, can appreciate the changes when considerably advanced? The birds, the fishes, the insects of to-day are the same that our grandparents knew. Linnæus would recognize our white-headed eagle, if he could see one now; yet, in truth, they are not wholly the same. Just as we will realize, in the coming May, a great change in the forest-trees, then clothed in verdure, and now bare and seemingly lifeless, will not, in the life-giving spring of a coming æon, the changes not now discernible be seen, admired, and studied, by the people of that time? Taking up some of the more familiar objects about me, I have endeavored to see if there was not a possibility of detecting some trace of changes now in progress, reminding one of the changes of a growing plant.

The change now in progress in any species, say of fishes, is to become, if I am correct in my surmise, visible in fifty centuries or more. From what we can now learn of the fish, can we determine the direction of the change; can we predict its character? Our slip of geranium has to-day a small outgrowth at one side of the stem; elsewhere the bark is smooth and unbroken. If, by the microscope's aid, we study the character of the structure of the main stem, if we learn every detail of the physiology of the plant, we conclude that it is a living, healthy organism, not depending upon the leaf-bud. As a mere bud, it is not a necessity; but, as a full-blown leaf, it is. If, now, we carefully study the habits of any of our common fishes, we will find in them certain peculiar habits, which may be compared to the leaf-bud; and I believe these habits, in many cases, are only faint traces of a coming change that will expand like the opening leaf-bud, into a fully-established characteristic in the far-distant to-morrow of a coming age.

In this way—to this extent—is not evolution visible?

As an example, let me call your attention to our well-known mud-minnow (*Melanura limi*). This fish I have very carefully studied for several years, and seldom fail to see something peculiar in its habits, every additional hour I spend in watching them, whether in an aquarium or their native haunts. On observing the movements of some remarkably large specimens lately, in an aquarium, I was forcibly struck with the peculiar use they made of their pectoral fins. These fins, in most fishes, are kept parallel, or nearly so, with the body, and are usually thin, transparent, and with very flexible rays. These conditions, which vary

in the thousands of species of fishes, do not obtain in the case of the mud-minnow The membrane is dense, the rays numerous and strong, and the fin is held at a right angle with the body when the fish is in an horizontal position, and nearly so whatever other position may be assumed. The ven tral fins, likewise stiff and strongly rayed, when the fish is swimming, are not much used, but as soon as the animal comes to a rest they are spread out, and, with the pectoral fins, now stiff and motionless, they form four legs that support the body, just as a salamander does. Indeed, the likeness goes further, and the body is curved frequently when at rest, and remains so; the head turned to the right or left, the tail in the opposite direction. No one can fail to see the salamandrine appearance of this fish in this position. Now, if we follow up the habits of the fish, what unfish-like—if I may use the expression—habit other than this can we detect? Knowing its predilection for thick and muddy waters, I find it not only conceals itself in the mud during the summer, but it deeply embeds itself and regularly hibernates; and in times of drought will live, as I have determined by experiment, twenty-eight days, in stiff mud, far less moist than the usual ditch-bottom, during a dry summer. This must be recollected in connection with its salamandrine aspects when in water. Again, by experiment, I find that this minnow, out of water, will outlive all other fishes of our streams, except the eel and possibly the catfish. My experiments showed it outlived a common sunfish just 500 per cent.; a roach, 1,500 per cent.; and a catfish and mud-minnow, taken from the water together, and kept thirty-five minutes in the air, were both very sick when replaced in the aquarium. The catfish revived in three minutes; the minnow in eleven. This unusual ability of retaining life out of its natural conditions and surroundings is just such a peculiarity as one might look for, in this species, having once noticed the peculiarity of the fins I have mentioned. To-day, however, I noticed for the first time a movement on the part of the mud-minnows, in my aquarium, never before detected, and which made the fins more leg-like than ever. Two specimens were resting, as we have described, on the tips of the pectoral and ventral fins. Coming near them suddenly, one, and then the other, moved several "steps," i. e., they gave their fins a leg-like motion, which left

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faint impressions, thus ( ( ( ( upon the sand. I had never seen such fin-movements on the part of this fish before, nor have I since, although for a week past I have carefully watched them.

Taking, now, into consideration the habit of resting on the tips of the fins; of giving the body a serpentine position, often maintained for many minutes; of burrowing in the mud; and able to withstand the atmosphere for a remarkable length of time; to which I think I may add walking on its fins—may we not see in all these a "leaf-bud," as it were, which in the far future will expand into an air-breathing, salamandrine animal?

Have we here really caught a faint glimpse of evolution?

Since the above was written, I have received and read Schmidt's "Descent and Darwinism." On page 130 he quotes from Lyell, as follows: "In a word, the movement of the inorganic world is obvious and palpable, and might be likened to the minute-hand of a clock, the progress of which can be seen and heard; *whereas the fluctuations of the living creation are nearly invisible, and resemble the motion of the hour-hand of a timepiece. It is only by watching it attentively for some time, and comparing its relative position after an interval, that we can prove the reality of its motion.*" This quotation is the same idea far more lucidly expressed; and, had I been aware of its existence, my remarks would have remained unwritten. As it is, are they not a confirmation of my belief that evolution is, after a manner, visible, and do we not find an instance of this in the mud-minnow?

CHARLES C. ABBOTT, M. D.

PROSPECT HILL, TRENTON, N. J., *March* 16, 1875.

# EDITOR'S TABLE.

### *TO OUR PATRONS.*

SIX volumes of The Popular Science Monthly are now published, and with this number it enters upon its fourth year. We remind our friends of this, that they may renew their subscriptions, and we trust they will urge their neighbors to join them in taking the Monthly, as thereby it may be obtained at a cheaper rate. The public press has been saying these three years that this is the most valuable and instructive magazine in the country. Yet our subscription list by no means comports with such a standard of excellence; for the best thing ought certainly to be the best sustained. Although our circulation is fair, it is still far behind that of those periodicals which leave science out or consign it to the department of scraps. Let no one suppose that in helping this Monthly to new readers they are ministering to a speculation; the time is a long way off when a first-class scientific magazine will enrich anybody. We have before us the more urgent question of making the Monthly pay moderate prices for the work that is done on it, and earn the means of its own improvement—objects which can be secured exactly in proportion as it is sustained by the public.

It should be remembered that The Popular Science Monthly stands alone in doing a special and important work. It was not started merely to add another to the list of magazines, the chief of which are so nearly alike that they are mutually replaceable; but it was started to furnish a very *different* magazine from any the people could get. In so far as our age is an age of ideas, the first great fact about it undoubtedly is, the ascendency of science as a power that is moulding the mind of the period. The extension of scientific knowledge is affecting all the interests of society. Agriculture, the manufacturing arts, locomotion, the physical conditions of health, the economy of the vital and mental powers, are all influenced by it to a degree never before experienced. These are confessedly within the circle of interests embraced by science, but that circle is steadily enlarging. Higher questions are being constantly brought under scientific treatment. To this great movement of thought characteristic of the time, our periodicals gave no adequate expression; and it therefore became necessary to begin a magazine that would put its readers in honest possession of the broadest conclusions of scientific study, as well as the immediate results of experimental research. Without being an organ of propagandism, or representing any clique or school of doctrine, we shall continue, as we have done, to give the fresh facts and the advanced conclusions of science, and we ask the earnest coöperation of all who sympathize with this work.

### *LACTOMETRY AND MORALS.*

There is an old disagreement between society and the milkman. The latter is alleged to be depraved, and, as a consequence, to adulterate his milk with water. Ethical considerations do not seem to influence him. Though commanded to sell unto others only such milk as he would have others sell unto him, he prefers what he considers as a still more golden rule.

Now, we are inclined to regard the milkman with becoming charity. We cannot believe that he is a sinner above all other men. What he needs more than any thing else is, to be delivered from

temptation. His evil opportunities are too many for him. Nor is it of much use to preach to him from the door-steps concerning the wickedness of his ways; because he will ask you to read from the newspaper you have in your hand the last reports about the rings, frauds, corruptions, stealing and plunder on a grand scale, in high places, and on the part of representative men whom the people delight to honor. Peculation, misappropriation, overreaching, and sharp practice, he tells you, are the order of the day—the rule, the fashion, and that a man "might as well be out of the world as out of the fashion." He tells you that business rivalries are desperate, that men must live, and that the world must be taken as it is. The milkman is of opinion that, if the business standards of the community could be raised to a level with his own practice, a long stride would be taken toward the millennium. He refers you to a report to the Board of Health in this city, in which it is stated that chalk, flour, starch, emulsion of almonds, sugar, gum, dextrine, borax, turmeric, annotto, soda, and sheep's brains, have been used for doctoring milk; but that, in hundreds of examinations of milk furnished to the citizens of this metropolis, none of these ingredients have been detected. Water, to be sure, is alleged to have been used, but what is more wholesome? and what are the secluded spring and the ready pump for, if not to supply it? He reminds you that societies are organized all over the world to get people to drink more of it; that milk is mainly aqueous, to begin with; that there is no natural standard of the proportions of this constituent; that the business of dispensing it is a detestable drudgery; that the milkman must be astir and abroad while other people slumber; that he has to rout the lazy servant-girls with unearthly screeches, and then wait till they are pleased to make their appearance; that there is waste with every pint delivered; that bills are hard to collect; that though his conscience be as white as the contents of his can, yet is he ever charged with cheating; that his rascally competitor is underselling him and he perfectly understands the cause; and, finally, that the losses and drawbacks of business have to be covered in different ways, while, if a little innocuous water is added to the milk, nobody is worse for it, and nobody can find it out.

Now, it is useless to reason with the milkman, or to exhort him to raise his conduct to the standard of pure and absolute rectitude, for, even if he should repent, he would be pretty sure to backslide. Yet the case against him is not to be given up; where homilies fail, science comes to the rescue; and, if its indications are followed, the milkman and his customer may be brought into tolerably harmonious relations.

How far the craft have wandered away from the paths of rectitude in this region, and how their venial transgressions swell into an immense daily burden upon the community, are well illustrated by the following statement from Prof. Chandler's report to the Metropolitan Board of Health in 1870. He says:

> "The average percentage of pure milk, in the adulterated article with which the city is supplied, is 73.28; or, in other words, for every three quarts of pure milk, there is added one quart of water. It was stated at the convention of milk-producers and dealers, held at Croton Falls, in March, 1870, that the total amount of milk supplied to the cities of New York and Brooklyn, from the surrounding country, was about 120,000,000 quarts per annum. To reduce this to the quality of our city supply, requires an addition of 40,000,000 quarts of water, which at 10 cents per quart, costs us the snug sum of $4,000,000 annually, or about $12,000 per day."

Now, granting that there is a great deal of money spent in New York, in worse ways than in buying water at ten cents a quart retail, it is still desirable to introduce more equity into these lactic transactions. The milk-consumer is

entitled to have what he pays for, and he can find out very satisfactorily what it is that he pays for, by the employment of the lactometer.

Good milk consists of about 88 per cent. water, combined with about 12 per cent. of solid matter dissolved or diffused in it, which makes it heavier than water. This increased relative weight is known as its specific gravity, and water being taken as 1000, the specific gravity of milk varies from 1023 to 1034. Without inquiring into the proportions of its several solid constituents, the lactometer determines their amount by indicating the specific gravity of the sample tested. The instrument is simply a glass tube closed at the lower end, and properly weighted, with a scale affixed, which shows the result when it is floated in a sample of milk. Milks from different cows and at different times vary in richness and poorness, so that it becomes important to fix such a standard that all samples which fall below it shall be classed as adulterated, or condemned as unmarketable. The New York Board of Health has been engaged for a considerable time, under the intelligent direction of Prof. Chandler, in investigating this subject, and, as a result of very extensive observations, they have fixed upon a specific gravity of 1029 as a fair minimum standard for pure milk, so that, "whenever the gravity falls below this number, the milk may be considered as containing an excess of water and consequently as poor in quality, or adulterated."

The standard adopted is, beyond doubt, sufficiently low. A German chemist tested the milk of 124 cows, and found the maximum specific gravity to be 1034.3, the minimum specific gravity to be 1029.5, and the mean 1031.7. Hence the standard of merchantable milk adopted by the New York Board of Health is lower than the poorest milk from these 124 cows. It may be remarked that milk of 1034 will bear an addition of 16.67 per cent. of water to reduce it to 1029.

This standard has been made legal in New York—that is, a dealer selling milk below 1029 is liable to a fine. Whatever may be the result of this policy, a most important step has been taken in fixing a minimum standard, and thus making it possible for milk-buyers, quickly and certainly, by the use of the instrument, to ascertain whether the character of the article they are purchasing is above or below it. We say, then, to every householder interested, get a lactometer. Taglibue, of 69 Fulton Street, New York, makes and sells them for $1.25 apiece, with the scale adopted by the New York Board of Health. The instrument is perfectly simple, and will last a hundred years, with care, but it is not a good thing for children to play with. On a card accompanying it, we read: "Fill the jar with the milk to be tested; allow it to cool to the temperature of 60° Fahr., then immerse the lactometer and notice the mark on the scale that is level with the surface of the milk, which will show the quality." The standard of pure milk adopted is marked P, and is taken as 100 on the scale. If the lactometer stands at that point, the milk is legal. If it sinks below it the milk is too thin, and the point in the scale at which it stands indicates its excess of water. If the mark P stands above the surface, the milk is richer than the standard, and the scale shows its superior quality. Of course, the instrument cannot give an analysis of the milk, and if a milkman reduces a high grade of milk to a somewhat lower standard, by admixture of water, the lactometer cannot show it; but it will tell exactly the quality of the milk every time, so that the buyer may know how he is being served. The general use of the lactometer could not fail to exert a beneficial influence upon the morals of the milk-trade.

### *DEAN STANLEY'S SERMON.*

In another part of the Monthly will be found a report, derived from the London *Times*, of a late discourse of the Dean of Westminster, which has made a profound sensation in England. It was delivered in Westminster Abbey, on a very impressive occasion, the funeral of a philosopher who had done more than any of his contemporaries to vindicate the sharply-contested doctrine of the government of the world by unvarying law rather than by providential interventions; and who, through evil report and much denunciation, had successfully asserted the vast antiquity of the earth and of the human race. To add to the solemnity of the occasion, if it were possible, the queen, the "Defender of the Faith," and the head of the English Church, caused to be laid on the coffin a memorial-wreath, as a mark of her esteem.

The guiding principle of Lyell's geological opinions was, that there never has been any variation in the laws and operations of Nature. This principle had long previously been established as the corner-stone of scientific astronomy, both in the prediction of future celestial events and in the verification of old observations. If an eclipse of the sun or moon be recorded by Greek, or Chaldean, or Chinese historians, the astronomer, without hesitation, resorts to retrospective calculations, and determines its exact date. Epochs in chronology have been settled in that way. Or, looking forward with prophetic eye, he declares that, at a specified moment, there shall be such and such a conjunction of the satellites of Jupiter, or, a century hence, a transit of Venus. Implicitly relying on forecasts of the kind, the position of the moon among the stars, and other phenomena of the celestial bodies, the mariner trustfully finds the place of his ship at sea, and determines his proper track. Nautical almanacs teach us what prophecy really ought to be.



Lyell transferred the principle from the heavens to the earth. He discovered that the modeling of her surface had been accomplished by forces that are now, and ever have been, in operation; that the summer sun and wintry frosts, that rains, and winds, and rivers, and glaciers, and the ocean, worked always as they work now. But this implied the lapse of enormous periods of time. The six days of the orthodox creation, and the 6,000 years of orthodox chronology, were absolutely inadequate.

Unwilling needlessly to give offense to those who were not emancipated from the legends of their childhood, who still linger among popular theological conceptions, and find difficulty in enlarging their field of view, he never offensively, but always modestly, put forth the consequences of his new facts, very often suggesting rather than proclaiming them. When the first discovery of the vast antiquity of the human race was made—a discovery in which he took a leading part—he scrupulously observed the same course, and in this set an example to those obstreperous theologians whose insolent denunciations of science are founded often on ignorance, and not infrequently on less excusable grounds. "We now know," says Dean Stanley, "perfectly well, from our increased insight into the nature and origin of the early biblical records, that they were not, and could not be, literal descriptions of the beginning of the world. It is now clear to all the students of the Bible that the first and second chapters of Genesis contain two narrations of the Creation side by side, differing from each other in almost every particular of time, and place, and order. It is now known that the vast epochs demanded by scientific observation are incompatible with the 6,000 years of the Mosaic chronology and the six days of the Mosaic creation."

We ask attention, in the interests of truth, to the grave import of these

words from one of the most learned and religiously earnest divines of our time. What do they imply? Two things inevitably: first, the abandonment to Science of those cosmological problems over which Theology has hitherto claimed a divine right; and, second, the surrender to critical investigation of the nature and source of those narratives which have been hitherto so implicitly trusted. Dean Stanley is far from being alone in his views; they are shared by many other eminent clergymen who recognize that the Mosaic account of the Creation is without authority; and yet no part of Dr. Draper's celebrated book on the "Conflict between Religion and Science" has been so bitterly denounced by theologians as his remarks on the authenticity of the Pentateuch. He ventured a bold prophecy that the originals of the legends of the creation, the garden of Eden, the development of Eve from one of the ribs of Adam, the fall of man, the Tower of Babel, and the confusion of tongues, would be discovered in the clay libraries of the revived Mesopotamian palaces, as that of the Deluge had been; and, already, though only a few weeks have elapsed, it appears that they have been so found. How are they to be interpreted? When the legend of the Deluge was discovered by Mr. Smith, the agent of the London *Telegraph* newspaper, in these cuneiform tablets, it was hailed with triumph by biblical scholars, who looked upon it as a wonderful and unexpected testimony vouchsafed to these later days in behalf of the story of Genesis and the authenticity of the Pentateuch. It was supposed that the universal deluge had now been proved to have taken place. But another and very different view of the case has emerged, which is, that these legends, instead of being corroborative testimonials of the Pentateuch narration, are rather the originals from which it was derived. Into the question thus opened, although of great interest, we do not enter, but may say that, if this view proves the correct one, Assyrian explorers will hereafter be at a discount. Their discoveries will be classed with those of astronomers, geologists, and anthropologists. The theologians will find in them matter for merriment; and the digger into the mounds of the Tigris must get ready to be denounced as an atheist.

And yet Dean Stanley's sermon inspires us with hope that a better day is dawning. In the highest ecclesiastical ranks—and remembering the flowers that were laid on the coffin—in the highest political ranks, there is arising a spirit of liberality which more than sympathizes with the life of those great and good men, who, like Sir Charles Lyell, do not hesitate to encounter the prejudices and ignorance of their contemporaries for the sake of the truth, who invest its pursuit with the sanctity of a religious duty, and consider practical piety to consist, not in the noisy clamor for dogmas about which the human race will never agree, but in a submissive study of the revelation of Nature, and a courageous declaration of what they find in its records.

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## LITERARY NOTICES.

Nature and Life. Facts and Doctrines relating to the Constitution of Matter, the New Dynamics, and the Philosophy of Nature. By Fernand Papillon. Translated from the second French edition, by A. R. Macdonough, Esq. New York: D. Appleton & Co. 363 pages. Price, $2.00.

The readers of The Popular Science Monthly cannot fail to learn with pleasure that the complete essays of this gifted young author are now accessible in a single compact volume to the American public. Several of Papillon's masterly articles have appeared in our pages, and they awakened so deep an interest in the subjects considered, and were read with so much admiration, that it was felt to be important that all his principal papers should be reproduced in a separate issue. Of the charac-

ter of these compositions it is hardly necessary to speak. They are not only written with great clearness, force, and eloquence, but they evince a subtile perception and a strong grasp of the higher problems of modern scientific thought. Beyond doubt the French lead the world in the arts of lucid and attractive scientific exposition; and Papillon stands eminent among his countrymen in the display of this excellence. Although dealing with the most complex questions, and surveying the great phenomena of life on all sides, and especially in its dynamical aspects, yet there are a glow and a fascination in his pages which we do not hesitate to say are unsurpassed in modern scientific literature. Nor has the work lost aught of these impressive characteristics in its English dress. Papillon has passed prematurely away, but Mr. Macdonough has done justice to his memory by this brilliant reproduction of the Frenchman's work, by which a distant and foreign people will be able to appreciate his genius.

Papillon's view as a thinker, and the spirit of his scientific studies, are so admirably presented in his brief preface, that we quote it in full:

"This volume contains a series of essays written and published at different times, some of a general character, and others more special, and all relating to the activity of natural forces, especially those of life. The mere bringing together of these fragments has presented an opportunity of completing a methodical and uniform whole, combining exactness in details with generality of doctrines, and distinctly tracing the precise aspect of each group of phenomena in the picture of the close and universal relations that bind the whole together. An exposition is thus offered under an elementary form, in language freed from technical dress, of the most essential truths established of late by physics, chemistry, and biology, regarding the mechanism of natural forces, and the arrangement and combination of the fundamental springs of being in the world, especially in the living world. I indulge the hope that such a work might meet a kindly welcome from minds, ever increasingly numerous, that regard science as the subject neither of idle curiosity nor of passing entertainment, but as the object of earnest sympathy and of serious examination. Such, at least, is the principal purpose of this book.

"It has another, also. The evident disposition of the present day is to repose infinite hopes on the natural sciences, and to expect unlimited benefits from them. I certainly shall not view this inclination as an illusion, and this volume sufficiently attests the high value I set upon all that can encourage and foster such feelings. But precisely because I am not suspected of enmity to those sciences, it has seemed to me the more necessary to indicate a fatal mistake accompanying those commendable sentiments; I mean the mistake of those who, after loudly praising the excellence of science, denounce the weakness and deny the authority of metaphysics.

"Now, my reader will come upon more than one page manifestly inspired by the conviction that science, properly so called, does not satiate the mind eager to know and to understand, and that therefore metaphysics holds a large and an authorized place in the activity of human thought. While I have retouched every thing in these essays which seemed to me, from an exclusively scientific point of view, susceptible of a higher degree of exactness and precision, I have, on the contrary, preserved with jealous care the literal tenor of all the pages expressly written under the influence of that conviction. And I have done so, not because of any peculiar value in those reflections, many of which are nothing more than a very imperfect representation of my way of seeing, but because those reflections were then made for the first time, with absolute spontaneousness, and without the slightest system or premeditation. The reader will thus be able to see how general ideas naturally emerge from deep and close contemplation of a group of various details, how forcible their unsought impression is; in other words, how surely thought, following orderly and regular evolution, without studied intention as without dogmatic aim, arrives at the loftiest philosophic certainties.

"The thinker who freely seeks for truth, continuously changes his position in his aspirations toward mind and the ideal. He deserts the regions of phenomena and concrete things, to rise to those of the absolute and eternal. The farther he withdraws from the former, which had at first absorbed all his attention, the more strikingly does the perspective in which he viewed them alter. At last, he discerns nothing else in them but spectres without substance, and delusive phantoms. And in the degree and extent of his drawing near to the eternal and the absolute, reality comes more surely

within his ken, and he gains a more vivid feeling and a keener conception of it. He measures the distance he has traversed, and values the worth of his own contemplations by the fullness of lucid clearness which enlightens his faint view of the first principles of things, and by the depth of humble reverence with which he bows before the mysterious Power which created all!

"CONCARNEAU (FINISTERRE), *May*, 1873."

THE MICROSCOPE AND ITS REVELATIONS. By WILLIAM B. CARPENTER, M. D., F. R. S. Fifth edition. 848 pp. Price $5.50. Philadelphia: Lindsay & Blakiston, 1875.

THIS standard work on the microscope has been carefully revised by the author, so as to present the latest improvements in modern instruments. It also includes the new methods and principles of Dr. Royston-Piggott, which have lately been the subject of so much discussion among microscopists; it likewise gives the latest results of microscopical study. It is a volume of goodly size, containing 449 woodcut-illustrations, and 25 plates illustrative of its wide range of subjects, and forming a standard and complete guide to the use of the microscope. The author's object throughout is to direct the possessor of a microscope in the *intelligent* study of any department of natural history for which he may have a taste, or his circumstances afford him the facilities of pursuit; and, again, to meet the wants of those who, coming to the study of minute animal and vegetable life with no scientific preparation, yet want something more than a mere sight of them. Of his use of scientific terms the author says:

"Some . . . may think that he might have rendered his descriptions simpler by employing fewer scientific terms. But he would reply that he has had much opportunity of observing among the votaries of the microscope a desire for just such information as he has attempted to convey; and that the use of scientific terms cannot be easily dispensed with, since there are no others in which the facts can be readily expressed. As he has made a point of explaining these in the places where they are first introduced, he cannot think that any of his readers need find much difficulty in apprehending their meaning."

Dr. Carpenter recognizes the impossibility of keeping pace with the rapid extension of knowledge over every part of the constantly-widening field of microscopic research, to say nothing of furnishing an exhaustive treatise on each of its many departments, in the limited compass of his book, the original purpose of which is to impart *general* guidance, rather than *special* instruction; and, instead of attempting the impossibility of teaching his reader all there is to be learned, he is put in the way of learning it from that best of all teachers, *experience*. And so, in the applications of the microscope, the proportion of space allotted to the different departments has been determined more from their special interest to the amateur microscopist than their physiological importance, and more space and treatment in detail are given to subjects having no special sources of information than to such as are the subjects of special treatises.

The first five chapters, embracing 269 pages of the work, treat respectively of the principles of the microscope, its construction, accessory apparatus, management of the microscope, preparation of objects, etc., while the rest of the work is devoted to the practical applications of the microscope in the study of minute forms of animal and vegetable life, and its uses in geology, mineralogy, and chemistry.

HEALTH; A Hand-book for Households and Schools. By EDWARD SMITH, M. D., F. R. S., Author of "Foods," etc. 198 pages. Price $1.00. New York: D. Appleton & Co.

UNDER the general title of "The Popular Science Library," it is proposed to issue a series of neat and attractive volumes at the moderate and uniform price of a dollar each, that shall treat of the most important and interesting scientific subjects in a way suited for general readers. The books will be original, translations, reprints, and abridgments, with illustrations when necessary, and will take a free range in the selection of subjects, giving prominence to those that are practical, but aiming to represent all the aspects of science which are of general or of prominent interest. Dr. Smith's volume on "Health" was issued first, and is a plain, practical, useful book, which aims only to give valuable information for everybody, in a form which anybody can under-

stand. Dr. Smith never paid much attention to the elegances of literature, and cared only to make his statements clear, intelligible, and adapted to the wants of his readers, and, while the pages of this little volume will be found to contain no fine writing, they are filled with compressed and simplified statements of extreme importance in relation to Food, Diet, Clothing, Exercise, Rest and Sleep, Cleanliness and Bathing, Ventilation, Mental Work, the Hygiene of the Senses, Personal Habits and Conduct, Sick-room Management, etc., etc. The volume is freely illustrated, and we know of no hand-book of health that contains within its compass more of the knowledge that should be universally diffused than this. It would be an excellent primary text-book of health for adoption in schools.

The Natural History of Man. By A. De Quatrefages. Translated from the French by Eliza A. Youmans. 12mo. Pp. 152. With Numerous Illustrations. New York: D. Appleton & Co.

POPULAR SCIENCE LIBRARY, NO. II.

This volume contains the substance of a course of lectures delivered to working-men by A. De Quatrefages, a distinguished Professor of Natural History at the Museum, in Paris, and one of the eminent founders of anthropological science. These lectures have been extensively circulated on the Continent, in different languages; and the translations of several of them, printed in this magazine, were received with such favor as to induce their republication in a connected form. Prof. De Quatrefages is an acute and discriminating observer, and an ardent cultivator of science, but with strong conservative tendencies of thought. At the outset he announces that he shall treat the subject not as a philosopher or a theologian, but in the pure light of natural science.

Contrary to Agassiz, he takes the ground that all men form but a single species, though of different races. He holds that the origin of man must be referred to a date much more remote than has usually been allowed, and that his original locality was confined to a narrow spot in Central Asia. As to the origin of man, Prof. De Quatrefages believes that science is unable to furnish any clew to the mystery, although he insists that, if science cannot say whence man came, it can say positively whence he did not come, and as a teacher of science he opposes the idea that man is a transformed and perfected animal. That the book may fairly represent the present state of opinion upon this subject the arguments on the other side of this question are briefly given in an appendix. As an elementary work upon this subject, these lectures will be found remarkable for clearness and simplicity of statement, felicity of illustration, vivacity of style, and skill in bringing large questions within the range of ordinary apprehension. It is the most admirable popular introduction to the races of mankind that has yet appeared.

Heredity: A Psychological Study of its Phenomena, Laws, Causes, and Consequences. From the French of Th. Ribot, author of "Contemporary English Psychology." New York: D. Appleton & Co. Pp. 393. Price, $2.00.

We cannot be too often reminded that it is the essential character of science to winnow, limit, verify, and extend the ordinary knowledge of mankind. The germs of science are given in common experience, and undergo gradual development, until they take the shape of proved and formulated principles. The subject of the volume before us forms an excellent illustration of this tendency. Heredity, or the transmission of qualities from parents to offspring, has been vaguely recognized as a verity of Nature for thousands of years; but it was at the same time considered so obscure and capricious a thing, that it could never be reduced to law, or become the proper subject-matter of science. But all that is now past. The principles of physiological heredity have been elucidated, and are now so clear and well established that they are brought to the test of every-day practice; and the law is so sure, that the skillful breeder is able to mould his stock in any direction, and to realize almost any ideal of desirable physiological characters.

In the world of mind, also, there has long been an uncertain recognition of the fact of heredity, and the descent of special mental traits in families is within nearly everybody's observation. But it was currently believed that such observations were

rare exceptions, and that nothing like a general law of the descent of mental traits could be established in the field of mind. But this error must now be regarded as abandoned. With the establishment of heredity as a biological law, or in the field of life, the presumption immediately became strong that it must also hold in the field of psychological phenomena. From the metaphysical point of view in which mind is regarded as an abstraction detached from organization, the law of heredity would probably never have been arrived at; but modern scientific psychology, which regards psychical phenomena as rooted and based in vital phenomena, passes naturally to the question as one of the necessary correlations of the higher organic science. And so it has come about that this principle of inherited mental predispositions and character, from being universally discredited as a baseless doctrine, is now admitted as a great truth, and not only so, but as a truth which forms the corner-stone of the latest philosophy. Among the students of mind, there is an old and inveterate quarrel about the origin of our ideas—one school holding that they are intuitions existing in an abstract mental world, and independent of all experience; and another school holding that all ideas are derivable from the experience of individuals. Herbert Spencer has shown that there is a partial truth in both these views, and that they are capable of essential reconciliation through the principle of the evolution of faculties by inherited experience.

So prominent has this doctrine become in recent inquiry, and so profound is its importance, that there has been an imperative need of some work that should deal distinctly and broadly with the subject, and present its scientific aspects in a form suitable for popular study. Such a work we now have from Prof. Ribot. Mr. Galton's work on "Hereditary Genius" is a valuable contribution to the subject, but it is very far from being complete in its exposition, and its main facts are presented in a form somewhat difficult for the reader to deal with. Prof. Ribot's work is systematic and full, taking up the subject under the four successive departments of the facts, the laws, the causes, and the consequences of heredity.

The following passage, from the conclusion of the work, will give an idea of the author's style, and of the method of his argument. In summing up all *facts* in favor of psychological heredity, he says:

"As regards specific characteristics" (i. e., those which distinguish one species from another), "heredity comes before us with the evidence of an axiom. In the physical, as in the moral order, every animal necessarily inherits the characteristics of its species. An animal which should possess, with the organism of its own species, the instincts of another, would be a monster in the psychological order. The spider can neither have the sensations nor perform the actions of the bee, nor the beaver those of the wolf. Just so in one and the same species, whether animal or human, the races preserve their psychical precisely as they do their physiological characteristics. . . . Under the specific form, then, mental heredity is unquestionable, and the only doubt possible would have reference to individual characteristics. We have shown, from an enormous mass of facts, that the cases of individual heredity are too numerous to be the result of mere chance, as some have held them to be. We have shown that *all forms of mental activity* are transmissible—instincts, perceptive faculties, imagination, aptitude for the fine arts, reason, aptitude for science and abstract studies, sentiments, passions, force of character. Nor are the morbid forms less transmissible than the normal, as we have seen in the case of insanity, hallucination, and idiocy."

The book consists of four parts, as we have remarked, under the headings indicated in the sub-title. In Part I. we have chapters on the Heredity of Instincts; of Sensorial Qualities; of Memory; of Imagination; of Intellect; of Sentiments and Passions; of Will; of Natural Character; of Morbid States. In Part II. the author devotes four chapters to a discussion of the Laws of Heredity, the titles being: "Are there Laws of Heredity?" the "Laws of Heredity;" "Essays in Statistics" (containing a criticism of Galton's great work); "Exceptions to the Law of Heredity." Part III. shows the dependence of psychological upon physiological heredity. In Part IV. we have chapters on "Heredity and the Law of Evolution;" "The Psychological Consequences of Heredity;" "Moral Consequences;" "Social Consequences."

Annual Report upon the Surveys and Explorations west of the One Hundredth Meridian. By Lieutenant George M. Wheeler, Corps of Engineers, U. S. A. With a Map showing the Areas surveyed up to the Close of the Field Season of 1873.

This is a pamphlet of 130 pages, issued from the Government Printing-Office, being Appendix F F of the Annual Report of the Chief of Engineers for 1874. It contains the report of Lieutenant Wheeler, in charge of the expedition, together with the reports of scientific researches made in connection with the survey. In addition to topographical work proper, the survey combines the establishment of numerous points astronomically; observations in meteorology and hypsometry; investigations in geology, mineralogy, and natural history; together with the collection of many other facts bearing upon the industries and resources of the regions traversed.

Notes on the Natural History of Portions of Montana and Dakota.

This is a pamphlet of 61 pages, emanating from the Boston Society of Natural History, and is the substance of a report made to the Secretary of War on the collections made by the Northern Pacific Railroad Expedition of 1873, by J. A. Allen, naturalist of the expedition. It comprises a description of the mammals, birds, reptiles, plants, and butterflies, met with in their route from the Missouri River to the Yellowstone, between the 46th and 47th parallels, and the 100th and 109th meridians.

Eighth Annual Report of the Board of Trustees of the Building Fund of the Academy of Natural Sciences of Philadelphia to the Contributors to the Fund. January, 1875.

This Report gives the list of subscribers from December, 1865, to December, 1874, as 461, of whom 39 are ladies. The total subscription is given at $203,965.24. This building fund is the result of a call made in 1865 for means to provide a new building, as their former limited space was becoming inconveniently crowded by new collections. The new building was begun July 9, 1872, on the north wing, which is expected to be ready to receive its collections in time for the Centennial, if the now nearly-exhausted treasury be sufficiently replenished for that purpose, an appeal for which is made in this Report.

On the Muridæ. By Dr. Elliot Coues, U. S. A. Reissued with Additions from the Proceedings of the Academy of Natural Sciences of Philadelphia, 1874.

The present pamphlet of 28 pages is the first of a series of preliminary zoological reports to be elaborated from the material secured by the United States Commission for the survey of the northern boundary, and of which Dr. Coues was the naturalist. The ground covered is the northern border of the Territories of Dakota and Montana, along the parallel of 49°, from the Red River of the North to the Rocky Mountains.

English Grammar. By the Rev. Richard Morris, LL. D. 115 pp. 18mo. Price, cloth, 40 cents; paper, 30 cents. Macmillan & Co., 1875.

This little book is the first of a forthcoming series of "Primers of History and Literature," edited by J. R. Green, M. A., Examiner in the School of Modern History at Oxford. It presents in a handy and concise form the practical principles of English grammar, together with much information seldom found in grammars of greater pretensions.

Preliminary Report upon Invertebrate Fossils collected by the Expeditions of 1871, 1872, and 1873, with Descriptions of New Species. By C. A. White, M.D. Government Printing-Office, Washington, 1874. 27 pages.

This preliminary report upon invertebrate fossils collected by Lieutenant Wheeler's expedition is made in order that the expedition may obtain due credit for priority of discovery, as nearly all the species noted are new. The pamphlet contains a full description, together with location, of some forty new invertebrate fossils.

Migrants and Sailors considered in their Relation to the Public Health. From Reports and Papers of the American Public Health Association.

This pamphlet, of 21 pages, comprises two papers: *A.* "Some Defects in the Immigration Service; Suggestions of Remedy therefor, with Reference to the Sanitary In-

terests of the Country. By John M. Woodworth, M. D., Supervising Surgeon United States Marine Hospital Service." *B.* "Sailors as Propagators of Disease;" Abstract of a paper entitled "The Hygiene of the Forecastle." By Heber Smith, M. D., Surgeon-in-charge United States Marine Hospital Service, Port of New York. The latter author gives diagrams of some representative forecastles, the sight of which is enough to condemn them. He shows how many of the gravest diseases are introduced and disseminated through communities to a greater extent by sailors than by any other agencies.

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### PUBLICATIONS RECEIVED.

An Analysis of the Life-form in Art. By Harrison Allen, M. D. Pp. 71. Philadelphia: McCalla & Stavely.

The Next Phase of Civil Progress. Pp. 43. New York: Dutton & Co.

The Glacial Epoch of our Globe. By Alexander Braun. Pp. 40. Price, 25 cents. Boston: Estes & Lauriat.

Protection and Free Trade. By Isaac Butts. Pp. 190. Price, $1.25. New York: Putnams' Sons.

Comparison of Certain Theories of Solar Structure with Observation. By S. P. Langley. Pp. 9.

Water in the Treatment of Disease. By V. Zolnowski, M. D. Pp. 39.

Vital Statistics and the "Military Reconstruction" of Louisiana. By S. E. Chaillé, M. D. Pp. 20.

Flora of Nebraska. By S. Aughey, Ph. D. Pp. 37.

Our Currency. By J. G. Drew. Pp. 43. Price, 20 cents. New York: Hinton & Co.

Irredeemable Paper Currency. Abridged from J. S. Mill's "Principles of Political Economy." Pp. 51. Price, 20 cents. New York: Hinton & Co.

The Cremation Theory of Specie Resumption. By David A. Wells. Pp. 19.

Measurement of Air-Angle of Microscope-Objectives. By R. B. Folles. Pp. 8.

Elements of Embryology (Foster & Balfour), Macmillan.

Elements of Mechanics (Nystrom), Porter & Coates, Philadelphia.

Birds of the Northwest (Coues), Government Printing-Office.

Improvement of Health (Knight), Putnams.

Lectures on the Teeth (Chase), Gray, Baker & Co., St. Louis.

Catechism of the Locomotive (Forney), *Railroad Gazette*, New York.

Maintenauce of Health (Fothergill), Putnams.

New Manual of Physiology (Küss, Duval, and Amory), Campbell, Boston.

Philosophy of Breeding (Sturtevant), Wright & Potter, Boston.

Composition of the Ground-Atmosphere (Nichols), Wright & Potter, Boston.

Brooklyn Journal of Education.

Population of an Apple-Tree (Packard), Estes & Lauriat.

Geological Survey of Alabama (1874).

Physical Features of Minnesota River Valley (Warren).

The Mammoth Cave and Some of its Animals (Putnams).

The Family Nemophidæ (Putnams).

Stevens Institute of Technology (1874).

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## MISCELLANY.

**The Fog-Signal Question.**—The elaborate articles on "The Atmosphere in Relation to Fog-Signaling," by Prof. Tyndall, which appeared in our March and April numbers, embodied the interesting results of a new and important research, and have attracted much attention, both on the part of our men of science and of many unscientific readers. There has been some dissent from his views, but Prof. Tyndall is quite easy about that. In a recent private letter he says: "A copy of the report of the United States Light-house Board, for 1874, has just reached me. I read certain portions of it with regret, but the questions it raises may be safely left to the judgment of the scientific men of the United States."

**A New Order of Mammals.**—At a recent meeting of the Connecticut Academy, Prof. O. C. Marsh called attention to the very peculiar character of the extinct animal type, *Tillotherium*. So remarkable, indeed, are these characters that Prof. Marsh considers them sufficient to constitute a new order, for which he proposes the name *Tillodontia*. In *Tillotherium*, the type of the proposed new order, the skull has the same general form as in the bears, but in its structure it resembles that of the ungulates. The molar teeth are of the ungulate type, and in each jaw there is a pair of large scalpriform incisors, as in rodents. The articulation of the lower jaw with the skull corresponds to that in ungulates. The skeleton mostly resembles that of carnivores, especially the *Ursidæ*, but the scaphoid and lunar bones are not united, and there is a third trochanter on the femur. The feet are plantigrade, like those of the bears. Thus these singular animals combine the characters of three distinct groups—carnivores, ungulates, and rodents. The order comprises two distinct families—*Tillotheridæ*, in which the large incisors grew from persistent pulps, while the molars have roots; and *Stylinodontidæ*, in which all the teeth are rootless.

**Animal Intelligence.**—The following remarkable examples of animal intelligence are sent us by correspondents who vouch for their truth: A lady living in this city relates that the house occupied by herself and family became so infested with rats that, in the failure of all other means, they were obliged to resort to poison to exterminate them. Phosphorus-paste was used, spread thickly over meat, which was then placed where the rats could readily get at it. Pursuing this plan for a long time, they were surprised to find that, while the meat regularly disappeared, the rats remained, their numbers apparently increasing instead of diminishing. One day a man in charge of an adjoining stable asked who was trying to poison rats, and, being told, replied, "the rats are too smart for you." He led the lady to the alley alongside the house, where there was a hydrant, the nozzle of which being broken off, left the water constantly running. Under the hydrant they saw several pieces of meat, some partially covered with, and others entirely destitute of, any traces of the phosphorus-paste. After watching some time, the lady actually saw the rats not only eat the washed meat, but carry the coated pieces carefully in their mouths from her back-door around into the alley, and deposit them under the running stream of the hydrant. Our correspondent says that the rats may not have known the character of the coating on the meat, but that their course argues a knowledge of the properties of water, and a power of adapting means to ends, akin to reason.

An esteemed friend writes us of a dog, that had been savagely set upon by a neighbor's dog, rousing up with a growl when the circumstance was spoken of in his presence. This was noticed, and, on repeating the circumstances, when the neighbor's name and that of his dog were mentioned, the growling was repeated. No effort was made to attract the dog's attention, and it was easy to excite the animal at any time by mentioning these names in his hearing.

A lady in Troy has a terrier, whose ability to understand what is said to him seems remarkable. The lady sent him one day to drive some chickens out of the yard, but doing it roughly the lady said, "See, some of the chickens are little, you must be careful not to hurt them." The dog immediately flew at the large ones, but drove the little ones with great care, and always afterward observed the same caution. This terrier attended church regularly with his mistress, but one Sunday another dog attracted his attention in church, and he ran out, afterward returning to the pew. After getting home the lady said, "Whiskey was naughty to-day; he mustn't go to church any more." The dog hung his head and went to his bed. He made no attempt to go to church that afternoon nor ever again, though ready to go anywhere else.

**The Deep-Sea Bottom.**—Prof. W. B. Carpenter, in a paper recently published in *Nature*, dissents from the conclusions of Prof. Wyville Thomson, that the organisms *Globigerinæ*, whose shells compose the ooze of the deep-sea bottom, live and multiply in the *upper waters only*. He has

found the water taken from 750 fathoms depth, and just above the ooze upon the bottom, turbid from the presence of multitudes of young *Globigerinæ*. The evidence is satisfactory to him that they live and propagate on the sea-bottom, as well as near the surface—that the young rise to the surface in the earlier stages of their existence, and become inhabitants of the upper waters, and in their adult stage sink to the bottom in consequence of the increasing thickness of their shells.

The cause of their sinking, therefore, is not death of the creatures, but weight of their shells. The thickening consists in a deposit of calcareous matter upon the outside of the proper wall after the creatures' full growth, which not only increases the weight, but alters the contour of the shell.

Prof. Carpenter cites the fact, noticed by himself, that, in cold areas of the seabed north of Scotland, no *Globigerinæ* were found, while the warm areas adjoining are covered with this peculiar ooze to an unknown depth. Why is this, he asks, if the surface only is their habitat, where the temperature of the cold and warm areas is the same?

**Priestleyana.**—The recent celebrations at Northumberland and Birmingham of the centenary of the discovery of oxygen by Dr. Priestley brought out many curious incidents in his career, and numberless anecdotes; we select the following as characteristic:

While he was minister at Leeds, a poor woman, who labored under the delusion that she was possessed by a devil, applied to him to take away the evil spirit which tormented her. The doctor attentively listened to her statement, and endeavored to convince her that she was mistaken. All his efforts proving unavailing, he desired her to call the next day, and, in the mean time, he would consider her case. On the morrow the unhappy woman was punctual in her attendance. His electrical apparatus being in readiness, with great gravity he desired the woman to stand upon the stool with glass legs, at the same time putting into her hand a brass chain connected with the conductor, and, having charged her plentifully with electricity, he told her very seriously to take particular notice of what he did. He then took up a discharger and applied it to her arm, when the escape of the electricity gave her a pretty strong shock. "There," said she, "the devil's gone; I saw him go off in that blue flame, and he gave me such a jerk as he went off! I have at last got rid of him, and I am now quite comfortable."

The destruction of Dr. Priestley's house and laboratory, by the riotous mob, at Birmingham in 1791, proved most disastrous, and the maddened crowd met with little opposition. "There was a small attempt by a few people to drive off the rabble, but they were compelled to show their heels by a shower of brickbats." The following amusing doggerel poem, which was published at the time, refers to this incident:

"The famous Dr. Priestley
Though he preached to admiration,
Yet he never could persuade
The unruly cavalcade
Not to show their detestation.

"They burned down both the meetings,
His manuscripts and papers,
And they swore it in their wrath
That they would not leave him worth
A single farthing-taper.—

"His house and all the utensils,
Out-offices and stable;
Nor durst the doctor stay,
But prudently got away,
And rejoiced that he was able."

The following epitaph, having reference to Dr. Priestley's peculiar religious views, was composed, before his death, by Rev. David Davis, one of the wits of the time. Dr. Priestley is said to have laughed heartily over it.

"Here lie at rest
In oaken chest
Together packed most nicely,
The bones and brains,
Flesh, blood, and veins,
And *soul*, of Dr. Priestley."

—Prof. H. C. Bolton, in *American Chemist.*

**Effects of Compressed Air.**—From Bert's researches it appears that meat does not oxidize and putrefy in compressed air—merely undergoing a change of color, consistency, and taste. But, on the other hand, muscular and nervous excitability disappear very rapidly in compressed air.

Thus the conditions of the two phenomena are different. Again, certain fermentations may be arrested by oxygen at high pressure; the mycoderma of vinegar is destroyed or killed by the action of compressed air. Wine may be preserved from acetous fermentation by submitting it to compressed air. It is necessary, then, to distinguish in fermentation various phenomena belonging to chemical actions, and those belonging to the action of ferments, properly so called. M. Bert adds that compressed air stops the putrefaction of meat even where the latter has been impregnated with putrid germs.

**Viniculture in California.**—This was the subject of a paper recently read before the California Academy of Sciences by Dr. James Blake. The author analyzed the juice of four different varieties of grapes, grown in the vineyard of the California Vinicultural Society at Sonoma, viz., the Zinfindel, the Reimer, the Riessling, and the Mission grape. The last-named grape was introduced into California by the Franciscan missionaries, during the Spanish domination; the others are recent importations. The method of analysis was to ascertain the specific gravity of the juice, which was then heated, to coagulate the albuminous matters, and filtered through a Bunsen filter. Then the juice was brought up to the original quantity, and neutralized with a standard solution of potash or ammonia, so as to ascertain the amount of free acid. Another portion was evaporated to about one-third, mixed with alcohol and ether to precipitate the tartrates, and the ether and alcohol distilled off from the filtered juice, which was then neutralized to ascertain the amount of malic acid. The amount of sugar, as indicated by the specific gravity, was controlled by direct analysis of a portion of the juice, cleared by acetate of lead, by means of Fehling's copper-test. The result was as follows:

| GRAPES. | Sp. Gr. | Sugar. | Free Acid. | Malic Acid. |
|---|---|---|---|---|
| Zinfindel ....... | 1072 | 16.6 | 1.73 | 0.60 |
| Riessling........ | 1083 | 18.7 | 1.10 | 0.57 |
| Reimer ........ | 1057 | 14.0 | 1.30 | 0.80 |
| Mission grape... | 1088 | 21.5 | 0.60 | 0.11 |

The small proportion of malic acid in the Mission grape explains the absence of aroma in the wine. The author attributes the failure to make first-class wine in California to two causes, viz.: 1. Bad quality of the grapes; 2. Injudicious choice of soil for vineyards.

**"The Successor of Steam."**—An article under the above title, by Dr. H. Beins, of Gröningen, has appeared in the *Chemical News*. The successor of steam is liquid carbonic acid. The author says: "For many years I have, with the collaboration of my brother, who is director of the Netherlands Soda Manufactory at Amsterdam, considered the question, 'How to transpose heat into mechanical power more advantageously than it is done in our common steam and other engines?' It occurred to me to make an experiment to see what degree the tension of the carbonic acid given off by natrium bicarbonate would amount to when heated in a closed space. We were surprised and much gratified to find that when natrium bicarbonate in a dry, pulverized state, or in a watery solution, is heated in a closed space, a part of the carbonic acid is given off and condensed in a not-heated portion of that space, so that, at a temperature of 300° or 400° C., liquid carbonic acid can be distilled out of this salt with a tension of from 50 to 60 atmospheres."

He then points out certain highly-important aspects of this fact: I. Carbonic acid of high tension, and, in particular, liquid carbonic acid, is an excellent motive-power for small and great industries. The weight of a carbonic-acid engine for ships, with 100 horse-power, and combustible stores for 240 hours, would be one-fifth less than the weight of a steam-engine of the same power. The former engine, too, will occupy less space. "I have experimentally found," he writes, "that a carbonic-acid engine is easily constructed. Taps and joints can be made to answer perfectly. A year ago I filled a tube of hammered copper with carbonic acid of 50 atmospheres, and not the least loss is as yet observed. Wrought metals are therefore not permeable for gases of that tension. For the great industries the carbonic-acid engine can, in almost every case, substitute the steam-engine. For the small industries, especially

for engines working with intermissions and during brief spaces of time, the property of liquid carbonic acid, of being always ready for work, is of much importance. By this same property, and since the mechanical equivalent of electricity is very small, such an engine is a very fit and cheap source of electrical light. My method of compression furnishes easily the required tension for the conveyance of letters in tubes, and the modern break-apparatus for railways." Further, the author suggests that his discovery might be turned to account in artillery, and in the construction of submarine vessels.

**New Eocene Mammals.** — Prof. Marsh is now contributing to the *American Journal of Science* a series of notices on new and hitherto undescribed mammals found in the Tertiary strata of the West. In the March number of the *Journal* he describes some new forms of quadrumana, a species of his new order *Tillodontia*, three species of rhinoceros, a new species of *Brontotherium*, and various other extinct animal forms. Among the quadrumana here described, we have a new genus, *Lemuravus*, closely resembling the lemurs in skeleton and in the general structure of the skull. The species *L. distans* was about the size of the largest squirrels. During the late raid into the "Bad Lands" of Nebraska, Prof. Marsh found the lower jaw of a monkey, which indicated an animal about the size of a coati; it is the first specimen of the order *Primates* found in that region, and forms a new genus and species—*Laopithecus robustus*. The order *Tillodontia* is represented by the new species *Tillotherium fodiens*. The animals of this order are among the most remarkable yet discovered in American strata. They seem to combine characters of several distinct groups, viz., carnivores, ungulates, and rodents. The *Tillotherium fodiens* would appear to have been about two-thirds as large as a tapir. The rhinoceroses described are *Diceratherium armatum*, *D. nanum*, and *D. advenum*. These animals had a pair of horns placed transversely, as in modern ruminants, as is clearly indicated by large, bony protuberances on the anterior portion of the nasal bones. The *D. armatum* would appear to have been about two-thirds as large as the Indian rhinoceros; the *D. nanum* was scarcely more than half the bulk of the preceding; while the *D. advenum* was half the bulk of the Indian rhinoceros. The new genus of *Brontotheridæ* is denominated *Anisacodon*, and it is represented by the new species *A. montanus*. According to the author, this family consists of four well-marked genera, viz., titanotherium, megacerops, brontotherium, and anisacodon. The name *Diplacodon elatus* is given to a new genus and species intermediate between *Limnohyus* and *Brontotherium*. Two new equine species from the Miocene are described, and three new species allied to the collared peccary.

**Premature Criticism.** — Mr. Proctor, in the *English Mechanic*, calls attention to a very curious piece of literary criticism occurring, of all places in the world, in the *Atlantic Monthly*. The critic is very severe in his sentence upon "The Sun," "The Orbs around Us," and other works by Mr. Proctor, but the value of his judgment is impaired by the evidence Mr. Proctor furnishes to show that it is not based on a knowledge of what is contained in the books. Among the works thus adversely criticised is "Other Suns than Ours." Of this Mr. Proctor says: "It may be as bad as he says; it may be 'trash,' and it may 'confirm the evil prognostic of its title,' but he might have waited till it was published. Three years ago, when it was half written, it was announced for early publication. Unfortunately for my critic (but fortunately for me), he has been led to suppose that the work accordingly appeared, and might safely be abused. But a great pressure of work prevented me from completing some stellar observations necessary for its illustration, and the MS. still lies unfinished in my desk. What a savage literary Herod a man must be who would thus slaughter the book unborn!"

**Fossils in Trap-Rock.**—The occurrence of fossils in trap-rock, though not uncommon, still awaits a satisfactory explanation. Mr. E. A. Wünsch, writing in a late number of *Nature*, mentions several instances of the presence of both plant and animal remains

in such rocks, and then has the following as to how they came there: "There is every probability that originally the enveloping matrix must have reached the fossils in the shape of volcanic ash, or, more likely still, in the shape of a thick fluid sediment enveloping the trunks of the trees as they stood erect, with their broken branches, leaves, and fruit scattered around them. We have numerous instances of ash-beds overlying limestone-beds containing corals, and I suspect Mr. Honeyman's '*trap rock in a fluid state*' would resolve itself into a rock of the nature above indicated; at all events, it would be very interesting to geologists on this side to receive specimens for closer examination. With regard to the possibility of fossils being inclosed and preserved in fluid lava, I may mention that when at Catania, in 1867, I was informed by Prof. Sylvestri that oak-trees on Mount Etna, when overtaken by lava-streams, are not actually annihilated, but the lava forms a sort of hollow cylinder around the trees, in which they are carbonized, and the silex contained in the wood collects in a fused mass at the bottom of the trunk. Such fused masses I met with at the foot of some of the stems of trees excavated by me at Arran, and numerous pebbles, evidently derived from the same source, are to be picked up on the shore between the Fallen Rocks and the Scriden at the north end of Arran."

**Curious Method of capturing Musk-rats.**—The *American Sportsman* describes the ingenious method followed by trappers in catching musk-rats: These animals often travel great distances under ice. In their winter excursions to their feeding-grounds they take in breath at starting, and remain under water as long as they can. They then rise to the ice and exhale the air in their lungs; this remains in bubbles against the under surface of the ice. They wait till this air recovers oxygen from the water and ice, and then, reinhaling it, go on till the operation has to be repeated. In this way they can travel almost any distance, and live any length of time, under the ice. The trapper takes advantage of this habit. When the marshes and ponds where musk-rats abound are frozen over, and the ice is comparatively thin and clear, they can be seen swimming about beneath. Following one for some distance, the trapper sees it come up to renew its breath in the manner described. After the animal has exhaled, and before it has time to take in the reoxygenized air in the bubbles again, he strikes with his hatchet directly over it, scattering the bubbles, and driving the musk-rat away. In this case the rat drowns in swimming a few rods, and the trapper, cutting a hole in the ice, takes it out. Mink, otter, and beaver, travel under the ice in the same way, and hunters, it is, stated, frequently take otters in the same manner.

**Education of Telegraph-Operators.**—In Holland the applicant for apprenticeship in a telegraph-office is required to present a thesis in Dutch; to be acquainted with French, English, and German; to know the first principles of arithmetic, common and decimal fractions, and the metrical system of weights and measures; to have mastered the rudiments of algebra and geometry, and in geography to be familiar with the situation of the various countries and principal towns. When an apprentice applies for the position of a telegraphist of the third class, he is required to pass an examination in magnetism, electro-magnetism, etc.—in short, to prove his familiarity with every detail of telegraph administration. Remarking on this, the *Journal of the Telegraph* says that in this country the person who enters the telegraphic service "must certainly know his telegraphic letters and make them correctly; must write a clear hand; must have a knowledge of circuits and office connections; and must be informed respecting the company's rules. Yet these simple requirements are objected to. 'I fear,' says the manager of a large office, 'if this were required here, I should be left almost alone.' We ask, 'Can this ignorance of the commonest knowledge of a great business be true?' We fear it is."

**How Water is injured by Organic Matter.**—In a recent work entitled "Scientific Conversations," by M. Porville, of Paris, the reason why organic matter becomes a dangerous constituent of water is thus set forth: "How does organic matter become dangerous? We must not believe that it

constitutes, as is superficially said, a toxic element. The phenomenon is more complex. The organic matter in suspension or in solution creates in the water a peculiar medium, suitable for the development of exceedingly small beings of the genus *Vibrio*. It is no longer mere water—it is a world of microscopic animals and plants which are born, live, and increase with bewildering rapidity. The infusoria find in the water calcareous, magnesian, and ammoniacal salts, and their maintenance is thus secure. Drink a drop of this liquid, and you swallow millions of minute beings. But there are vibrios and vibrios. There are those which are capable of setting up putrefaction in our tissues. These are our enemies, often our mortal enemies. Let water be placed in contact with organic remains capable of nourishing these malignant vibrios, and it at once becomes more dangerous than any poison."

**A Motherly Fish.**—There is found, in the clear, pebbly streams which descend to the plains from the mountain-ranges of Trinidad, a small fish of the perch tribe, which in its great care for its young presents a singular contrast to all other known fishes. A writer in *Nature* states that on one occasion, as he approached the water for the purpose of taking his morning bath, his attention was attracted by the eccentric movements of one of these little fishes. In general they are very shy, scudding off into deep water on the approach of man; now, however, when a hand was put into the water, the fish darted forward again and again, striking the hand with considerable force. The explanation of this conduct was soon found: in a small hollow near by, about the size of half an egg, artistically excavated in the bright quartz-sand, a multitude of tiny fish were seen huddled together. They had apparently been very recently hatched, and were no larger than common house-flies; the parent-fish kept jealous watch over her progeny, resenting every attempt to touch them. Returning to the same spot on the following day, the writer of this narrative searched there in vain for the fish and her young. At length, however, a few yards farther up stream the parent was discovered guarding her fry with zealous care in a cavity similarly scooped out in the coarse sand; any attempt to introduce one's finger into the nest was vigorously opposed by the watchful mother.

**Arsenical Colors.**—A Swedish chemist, Dr. Hamberg, has made some important researches on the arsenical coloring-matters of wall-paper. The paper of the room in which the experiments were conducted had a light-green ground, with an ornamental pattern of brownish-yellow color; this yellow was probably derived from an ochre, but the green resembled Schweinfurt green, and was strongly arsenical. An arrangement was made for drawing a current of air through a series of U-shaped and bulbed tubes, suspended on the wall. The passage of air was continued from July 16th to August 16th, and it was calculated that during this time about 2,160,000 cubic centimetres of air had traversed the system of tubes. Some of the tubes had been plugged with cotton-wool, while others contained a solution of nitrate of silver, and at the termination of the experiment the contents of the tubes were separately examined. The results showed that there had been an arsenical exhalation. The family living in the house had never suffered any marked injury from breathing this poisoned air; but Dr. Hamberg, after sleeping in a room by the side of the apartment in which his experiments were made, and with the door open, frequently experienced, on the following morning, a sense of heaviness in the head, and a general feeling of weariness.

**Distribution of Water in Aquaria.**—In constructing aquaria it is important to bear in mind the fact that, for aquatic animals which breathe without lungs, the value of water does not depend so much on its amount, as upon its distribution in such a manner that it may be sufficiently oxygenated by contact with the atmosphere. Mr. W. A. Lloyd, who calls attention to this matter in the *Zoologist*, says that when the amount of surface of water exposed to air, as well as the actual quantity of water, is regulated according to the known requirements of the animals to be kept, the well-being of the creatures is promoted, and the

cost of constructing and maintaining aquaria considerably diminished. This principle is applied in the transportation of living aquarium animals to considerable distances. Take, for example, a fish packed in damp, freshly-gathered sea-weed. Its gills are kept wet by such very thin films of water that their thinness, otherwise shallowness, enables them to be constantly oxygenated by contact with the atmospheric air. Thus the gill-filaments are kept wet and separate from one another, and the blood flows uninterruptedly through them, being aërated as it does so.

**The Origin of the Potato.**—Mr. Meehan, of Philadelphia, has for eight years cultivated *Solanum Fendleri*, a solanaceous plant which has much in common with the potato (*Solanum tuberosum*). His object was to ascertain whether the former could be transformed into the latter by cultivation, and so to settle the vexed question of the origin of our common esculent tuber. It was not till last year that the plant began to vary in the direction of the potato. Previously, the tubers were round, about the size of a large bullet, and rugose from the imperfect tube-cells on the surface. Last season, however, the roots began to resemble those of the potato. They were oval and compressed, and one was an inch wide and two inches long, with a clear, semi-transluscent skin, as in the more delicate potatoes. Mr. Meehan, however, does not expect to develop potatoes from his wild solanum; according to him the facts so far obtained do no more than suggest the possibility of the unity of origin of the *Solanum Fendleri* and the *S. tuberosum*.

**Cultivation of Jute in the South.**—The cultivation of jute in the southern portion of the United States seems destined to become, at no distant day, a highly-profitable industry. Notwithstanding the many difficulties and drawbacks of the past season—deluging rains, overflows of rivers, and droughts—it was expected that the harvest in Louisiana would be satisfactory. In a letter to the Department of Agriculture, Mr. Emile Lefranc, of New Orleans, President of the Southern Ramie Association, describes some of the fields as splendid, growing eight feet high, and as thick as wheat. The forthcoming report of the Department will contain a description, with illustrative drawings, of Lefranc's jute-cleaning machine. This machine will produce over a ton of clean fibre per day, with four attendants only. It cleans jute, ramie, and okra radically, and without waste, and it is believed that hemp and flax may also be treated with it with equally satisfactory results.

## NOTES.

S. Augusto Guattari, of Castellamare, Italy, has devised an improvement in pneumatic telegraphs, consisting of an instrument which will serve either as a transmitter or receiver. By means of two such instruments, placed at different stations and connected by a single air-conducting tube, messages may be transmitted in either direction. There is but one dial, which serves to indicate both the signals sent and received, so that the same instrument is made to answer both purposes, thereby dispensing with one of the two required in all other pneumatic telegraphs, and lessening the cost of apparatus. The invention has been patented here.

Dr. John Edward Gray, F. R. S., naturalist of the British Museum, died March 6th, in the seventy-fifth year of his age. He was a voluminous writer on zoological and botanical subjects. He was connected with the Natural History Department of the British Museum for over fifty years. In addition to his strictly scientific work, he took part in the discussion of various questions of social importance, such as public education, prison discipline, the postage system, and the organization of museums and galleries of art.

Died at Bonn, on the 17th of February, Prof. Friedrich Wilhelm August Argelander, the celebrated astronomer. Deceased was born in 1790, and in 1820 became the official assistant of Bessel at the Königsberg Observatory. From 1845 till his death, he was in charge of the observatory of the Bonn University. His "Celestial Atlas," lately published, ranks among the best works of its kind.

"The isolated study of any thing in natural history is a fruitful source of error. . . . . No single experiment in physiology is worth any thing."—Dr. Jeffries Wyman.

A manual is to be prepared for the use of the British Arctic Expedition of next summer, consisting of reprints of papers in the transactions of learned societies not otherwise accessible, and other materials, the ob-

ject being to furnish an exact view of the state of existing knowledge of Greenland and the surrounding seas.

In Osage County, Kansas, the fruit-trees which had been stripped by the grasshoppers all put forth leaves again, and many of them bloomed with double flowers; most of the embryo fruit was double.

From the researches of Charles Violette on the distribution of the saccharine and saline principles in the beet, it appears that the former increase considerably by arithmetical progression from the collar to the point of the root. The saline constituents do not show a regular variation in quantity from one end of the beet to the other, still the chlorides are more abundant at the collar than at the point.

The Agassiz Memorial Fund has been accepted by the President and Fellows of Harvard College, for the use of the Museum of Comparative Zoology founded in that university by Agassiz. The continuous growth of the museum is thus assured.

"Mumbo Jumbo" is commonly supposed to be the proper name of an African god; in reality he is a sort of policeman, an institution peculiar to the Mandingoes on the river Gambia. A traveler in Africa informs us that he is the terror of the Mandingo women, for whose special benefit and discipline he has been established. A strong, athletic man, dressed from head to foot in dry plantain-leaves, appears when invoked by an injured husband. He goes through all sorts of antics and pantomime among the assembled villagers, all of whom are there under pain of suspicion. Suddenly he pounces like a tiger upon the offending wife, and thrashes her severely with a long rod with which he is armed. The crowd, especially the women in it, drown her cries with jeers and laughs. In other parts of Africa a similar domestic policeman exists.

M. d'Ommalius d'Halloy, the distinguished Belgian geologist, died at Liége, January 15th, at the age of ninety-two years. He was the author of several text-books on geology, as also of numerous memoirs contributed to learned societies and scientific periodicals.

An aquarium-car containing 300,000 fishes for California waters was wrecked last year *en route*, and its living freight precipitated into the Elkhorn River. Another attempt at introducing into the streams of the Pacific slope some of the valuable food-fishes of the Atlantic coast was more successful. Mr. Livingston Stone, of the United States Fish Commission, started from Albany on the 25th of June with about 40,000 young shad. Of these, 5,000 were placed in the Jordan River, a tributary of the Great Salt Lake, and the remainder in the Sacramento.

The monthly report of the Department of Agriculture states that last year the "chinch-bug," which usually restricts its ravages to growing Indian-corn, in Johnson County, Missouri, attacked potato-vines, and even the tobacco-plant.

In the peat-bogs of Northwestern Germany a peat-cutting machine is employed, consisting of a large, flat-bottomed steam-vessel, which, when set to work, is able to cut a canal 20 ft. in breadth and 6 ft. in depth, while proceeding at the rate of from 10 to 12 ft. per hour. The soil thus cut out is lifted into the vessel by steam-power, there thoroughly ground, and deposited, by means of a pipe running out of the side of the vessel, on the bank of the canal, where it is subsequently cut into bricks and dried. By this method about 55 tons of very good peat may be manufactured per day. A similar machine is also in use in Canada.

A medical officer of the British Navy recommends that each member of the projected Polar Expedition have fitted to his *sacrum* a flat spirit-lamp, from which a tube should pass up the spine beneath the clothes to the occiput, so as to maintain the heat of the trunk and vital organs!

By invitation of the Senatus Academicus of the University of Edinburgh, Prof. Huxley will perform the duties of the chair of Natural History in the coming summer session, in the place of Prof. Wyville Thomson, who is absent with the Challenger Expedition.

A quarterly review of scientific psychology and philosophy will be issued in London in the course of the present year. It will discuss many subjects at present but little attended to in psychological journals, such as language, primitive culture, comparative psychology, etc. The title of the new periodical will be *Mind*.

A monument is about to be erected in Stockholm to Scheele, the great Swedish chemist, who discovered tartaric acid, chlorine, baryta, and glycerine; he also discovered oxygen in 1777 in the course of his own independent researches, though the honor of prior discovery belongs to Priestley. A monument is also to be erected in Brussels, to Quetelet, the illustrious statistician.

In the Freedmen's Mission Chapel at Green Cove Spring, Florida, a circular saw, about three feet in diameter, serves as a bell to call the people to prayers. The saw is suspended from a rafter, and it is sounded by means of a wooden mallet. This "bell" is heard, in calm weather, at the distance of a mile and a half.

CONVENTION OF THE TOADSTOOL FAMILY.

THE

POPULAR SCIENCE MONTHLY.

JUNE, 1875.

# TOADSTOOLS AND THEIR KINDRED.

By Miss E. A. YOUMANS.

IN taking "toadstools" as the text of a little botanical discourse, we start with a familiar notion if not a scientific one; but all science begins with common ideas which it corrects, extends, and develops. Everybody knows what toadstools are, odd-looking things that grow up in the fields and are often kicked aside in rural rambles, of no use to man or beast, and "pizen" to eat. This is the oldest, the widest, and the lowest state of mind upon the subject. But many have got beyond this, and recognize that some of these queer-looking things are actually eatable; these they distinguish as mushrooms, and all the rest are lumped together as toadstools. A step forward, and we become slightly scientific; that is, the different kinds begin to be noted, and compared, and classed with reference to their particular characters. When so much is gained, it soon appears that the subject is much wider than was supposed, and that all these growths are but parts of an extensive division of peculiar plants called *fungi;* and, having reached this state of intelligence, toadstools have disappeared. While, then, the popular term may answer to indicate generally what we are talking about, it conveys no exact meaning. The group of plants represented upon the plate is not merely a family of toadstools, but a collection of fungi. By their unlike characters they belong to separate groups in this class, and each has its separate name;[1] for nomen-

[1] NAMES OF SPECIES SHOWN IN THE PLATE: 1. Fly-blown mushroom—*Agaricus muscarius.* 2. Common mushroom—*Agaricus campestris.* 3. Round-headed morel—*Morchella esculenta.* 4. Small-headed morel—*Morchella hybrida.* 5. Tall cylindrical agaric—*Agaricus comatus.* 6. Variable wood agaric—*Agaricus gilvus.* 7. Shaggy agaric—*Agaricus floccosus.* 8. Spangled watery agaric—*Agaricus micaceous.* 9. Warty false puff-ball—*Scleroderma verrucosum.* 10. Large bladder-like peziza—*Peziza vasculosa.* 11. Alpine amanita—*Amanita nivalis.* 12. Red-stemmed boletus—*Boletus luridus.* 13. Scaly hydruim—*Hydruim imbricatum.* 14. Hairy earth-tongue—*Geofclossum hirsutum.* 15. Hispid polyporus—*Polyporus hispidus.* 16. Sulphur-colored polyporus—*Polyporus sulphureus.* 17. Carmine peziza—*Peziza coccinea.* 18. Scaly hydruim—*Hydruim imbricatum.* 19. Pale-

clature must keep pace with science, and its higher discriminations require separate technical terms to mark them. Some people cry out against a few strange words in botany, and make it an excuse for neglecting the study; but the real reason is, a lack of interest in the knowledge of Nature, for they are generally ready enough to spend whole years in the acquisition of strange words by the thousand in foreign languages, living and dead. Scientific terms have an educational value, because they involve and give precision to new ideas, while in acquiring an additional language we are only obtaining new terms for old ideas.

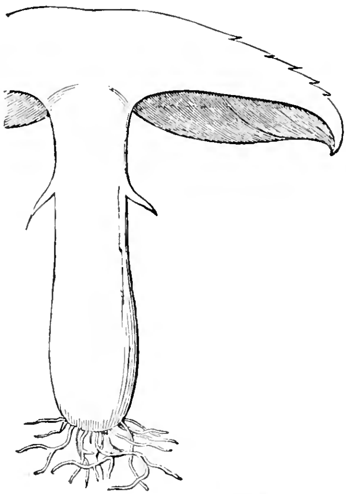

FIG. 1.—SECTION OF COMMON MUSHROOM.

Of all the common objects of the country, toadstools seem to be least related to surrounding things. Neither in form, nor color, nor apparent origin, nor distinguishable parts, do they resemble other plants; and scientific scrutiny must replace common observation before the first step in their classification can be taken. At the very outset of study the botanist is struck by their paradoxical character. In rapidity of growth and speedy decay they are more allied to low animal than to vegetal forms. Like animals, they feed upon organic matter. Their substance is rich in nitrogen, has a savory meat-like taste, and when decomposing gives out a strong, cadaverous smell. They absorb oxygen and disengage carbonic acid, and by their avoidance of light they present a striking contrast to the rest of vegetation. Nevertheless, careful observation shows that they consist of parts, and

crested agaric—*Agaricus cristatus.* 20. Mitral helvela—*Helvela mitra.* 21. Tuberous agaric—*Agaricus tuberosus.* 22. False puff-ball—*Scleroderma cepa.* 23. Large-stemmed peziza—*Peziza macropus.* 24. Green and yellow agaric—*Agaricus psittacinus.* 25. Crisped helvella—*Helvella leucophæa.* 26. Reticulated peziza—*Peziza reticulata.* 27. Yellow spathularia—*Spathularia fuvida.*

perform functions, by which they are allied to all other plants and closely related to one of the largest groups of the vegetal kingdom. They stand, in fact, at the head of the class of fungi, of which there are at least as many species as of all flowering plants put together.

These singular forms, though low in the scale when compared with the green and blossoming world around us, are yet complex and imposing when contrasted with the world of plant-life revealed by the microscope. They have a distinct vegetative system, and a highly-organized reproductive system. On examining the common cultivated mushroom, a species which grows wild in meadows and pastures, these separate systems may be readily distinguished. The vegetable mould or decaying substance on which it grows is penetrated with grayish-white delicate interlacing filaments which are represented by the root-like fibres shown in Fig. 1. This webby mass constitutes the vegetative portion of the plant. It is called the *mycelium*, or, among dealers, the spawn, as by its means the plant is propagated in cultivation. In a dry state it may be kept dormant for a long time, and will grow into a perfect plant under the influence of heat, moisture, and other favoring conditions.

From this mycelium arises the reproductive system—that portion of the mushroom which is seen above-ground and which may be compared to the inflorescence of higher plants. It consists of the long thick stem or *stipe* and the umbrella-like top, called the cap or *pileus*. On the lower surface of this cap vertical plates are seen radiating from the stem, though not connected with it. These plates are known as *gills*, and in a living specimen they will be found covered on all sides by a delicate membrane called the *hymenium*. Upon this hymenium are borne the reproductive bodies or *spores*, which are analogous to seeds.

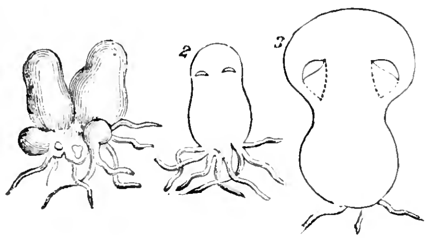


Fig. 2.—Mushroom in Process of Growth.

To make our conception of the structure of this mushroom more complete, we will trace its growth from the beginning. The first visible portion is the mycelium, at certain points of which there appear, at an early stage, round tubercles not larger than a mustard-seed, which rapidly increase in size, push through the soil, and become more or less elongated, resembling the shaded cut in Fig. 2. There is yet no external sign of cap or gills, but a section of the tubercle will reveal

a pair of dark-colored spots near the top (*see* 2 and 3, Fig. 2), which mark the position of the future gills. A little later the cap begins to take shape, the gills develop, and a membrane may be seen stretching from the stem to the edge of the growing cap. As maturity approaches, this membrane is ruptured and forms a ring around the stem, as shown in Fig. 3. This membrane is called the veil or

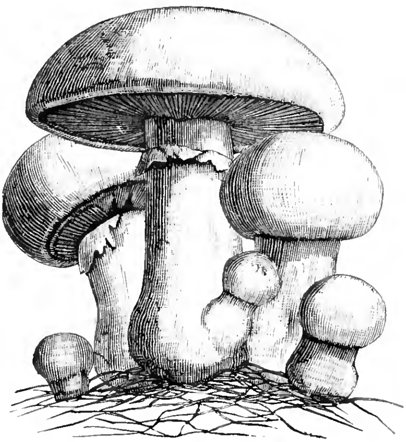

Fig. 3.—Common Meadow Mushroom.

*volva*. The parts to be borne in mind, then, are the mycelium or vegetative portion, and the stem, cap, gills, hymenium, ring, and volva, all of which belong properly to the reproduction of the plant, and all, except the hymenium, may be readily traced in Fig. 3.

If, when the mushroom is mature, you cut off the stem close to the gills, and place the cap, gills downward, upon a sheet of paper for a few hours, or all night, it will leave behind a likeness of itself in the shape of radiating lines that correspond to the spaces between the pairs of gills. These lines are formed by minute microscopic spores that have been thrown down in profusion from the hymenium, and in greatest number from the opposed surfaces of the gills. In making the experiment with this mushroom use white paper, but for light-spored species black paper should be taken. These little germinal bodies are cellular in structure, and of the extremest minuteness; thousands of them are required to form a body the size of a pin's-head. Their color is constant, and is used as a means of identification; but among the higher plants color is a character that cannot be thus relied upon. The spore is a simple cell, and the entire mushroom is cellular in composition. The delicate threads of the mycelium are formed of rows of cells placed end to end, and microscopic inspection of thin slices from the stem and cap show, that they also are composed of cells alone.

The rank of this plant in the vegetal kingdom is settled by the direction of growth of its vegetative system and by the nature of its tissues. All flowering plants, as well as the ferns and mosses, have their vegetative part made up of root, stem, and leaves. The root grows downward and the stem upward. But the growth of the mycelium, the vegetative system of the mushroom, is horizontal; there are no signs of such organs as root and stem. In this respect it is on a level with lichens and sea-weeds, and belongs at the foot of the scale in vegetation. As respects the nature of its tissues and the absence of woody fibre in its composition, it resembles all the flowerless plants except ferns. But where are its immediate kindred? Have mushrooms no nearer relations than mosses, lichens, and sea-weeds?

To answer this question intelligently we must further observe the structure of fleshy fungi. In the common mushroom, as we have seen, the hymenium is spread out upon the lamellated structure of the gills—an arrangement, however, which is not general. It is peculiar to a single group known as agarics. This group has also the further general characteristic of preferring to grow in shady places. But in this latter respect the common mushroom is an exception. In its wild state it flourishes best in meadows and pastures. Its scientific name is composed of two words: one tells us the immediate group of toadstools to which it belongs, and the other expresses this exceptional feature in its constitution. The one which is put first is its family or surname, *Agaricus;* and the specific name, or what we may call the "given" name, is *campestris* (meaning field). These names are written in Latin for the convenience of the botanists of different nations speaking different tongues, but for whom the Latin is a common medium of communication.

Fig. 4.—Polyporus Giganteus (reduced).

Now, the structure of the under portion of the cap in some toadstools is porous instead of lamellar. The surface of the spore-bearing hymenium is multiplied by means of pores or tubes which penetrate the substance of the cap, as seen in Fig. 4. Two stemless species of this sort are shown in the plate as growing upon an old tree.

Sometimes this under surface is seen to be quite smooth, or it

may be simply wrinkled; sometimes it is warty or prickly, and in Fig. 5 it is represented as covered with spines. Again, in some species of fungi, the hymenium, instead of being situated externally, is inclosed in a membrane which bursts when its spores are ripe, and scatters them like a cloud of smoke to the winds. Of such is the puff-ball, Fig. 6, with which everybody is familiar.

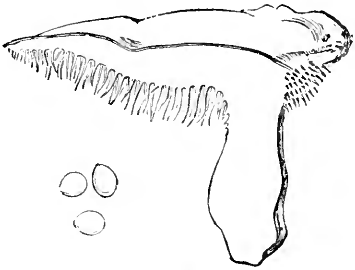

Fig. 5.—Hydnum Repandum.

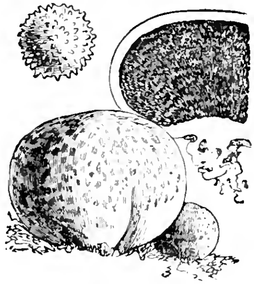

Fig. 6.—Scleroderma Vulgare.

These fleshy forms, however, although very numerous, constitute but a small part of this immense group. But most of the species included in it are either quite invisible, or else the parts which characterize them as fungi are so small as to be indistinguishable. The feature by which a fungus may always be known is the mycelium. Every plant of which this structure forms a part, spreading its web throughout the substance on, or in, which it grows, belongs among fungi. They differ among themselves in such comparatively unimportant respects as the mode of growth of the hymenium, or the degree of complexity of the reproductive system, but mycelia and spore production are their essential characters. In these diminutive organisms, the delicate mycelium is so minute as to traverse living plants and the pores of solid wood. The potato-rot is such a fungus—a sort of mould—the mycelium of which grows rapidly, penetrating the leaves, stem, and tubers, and causing quick decay. Dry-rot in timber is occasioned by the penetrating mycelium of fungi. The yeast and vinegar plants are submerged mycelia. The mildews, rusts, and smuts of grain—those scourges of the farmer—are all fungi. Their minute mycelium penetrates and destroys the tissues of plants, and, bursting through the cuticle, covers them with myriads of their orange, brown, and black spores. All those black, pustular growths seen on dead wood, bark, twigs, and leaves, and the whole tribe of moulds that cover every substance exposed to dampness, are fungi. Not only do these fungi ravage the living and the dead, but they fill the air with the countless myriads of their spores. These subtile particles, "invisible to the naked eye, and light almost as vapor, are continually floating in the air we breathe, or swimming in the water we drink, or lying amid the impalpable dust and sand of the soil, waiting the presence of warmth

and moisture to burst into independent life. Myriads of the minute germs of moulds fasten upon various domestic articles, or dance about in the air-currents of our apartments, moving rapidly up and down and in every direction. The microscopist and the chemist have demonstrated the existence of these germs in greater or less quantity in the air of both country and town, out-of-doors as well as in-doors; and Prof. Tyndall by calling in the aid of optical analysis has, on this point, made assurance doubly sure. If we venture for a moment to imagine the overwhelming number of seeds which the different species of fungi must disseminate in the course of a single year—if we consider that each individual of the common puff-ball contains upward of ten million seeds, and these so small as to form a mere cloud when puffed into the air; and that a single filament of the mould which infests our bread and preserves will produce as many germs as an oak will acorns, so that a piece of decaying matter, not two inches square, will scatter upon the air, at the slightest breath of the summer breeze or the gentlest touch of an insect's wing, as many seeds, quick with life, as all the oaks of the country will produce acorns in a twelvemonth—if we take these things into consideration, it is not too much to suppcse that the seeds of fungi must be ubiquitous, and from their excessively minute size penetrate into every place, even into the stomachs and other parts of animals. Indeed, the difficulty seems to be to imagine a spot without them."

But, in looking up the relatives of the mushroom, we have been led too far away from the study of its structure. Recurring to the species with which we began our study, and a cluster of which, at different stages of growth, is represented in Fig. 3, let us inspect it once more, and make sure that we have a clear notion of all its parts. Observe the mycelium at the base, the stem, the unbroken volva in the young ones, the beginning of its rupture in a more advanced stage, and, finally, at the end of growth, the fully-developed cap, with its gills, and the ring left by the volva upon the stem. After this account of its structure, its specific description should be quite intelligible to anybody, and ought to suffice for the ready recognition of the living plant. It is as follows:

*Cap* fleshy, either smooth or scaly; its color is white, or tawny, or smoke-colored, or brown; *gills* free, when first formed pale, then changing to flesh-color, then to pink, next to purple, and, at length, tawny-black; *stem* white, full, firm, varying in shape, with a white persistent ring. Spores brown-black; volva quickly disappearing. In his recent work on "Fungi and their Uses," Cooke says of this plant that the color of the spores and gills, and the presence of the ring, are characters that never vary, but the color and scaliness of the cap, and other minor features, are variable; and, furthermore, he enjoins that it must not be sought in the woods. Its proper season is September and October.

There is another common, though much coarser species of edible mushroom, often mistaken for this one, and sold as such by dealers. Although it resembles the cultivated species, it may be easily distinguished by its big, ragged ring (Fig. 7), its pithy stem, tending to hollow, and its gills of a dirty-brownish white. It is also much larger,

Fig. 7.—Agaricus Arvensis.

being sometimes more than a foot across, while the common mushroom rarely exceeds three or four inches; in good specimens its top is smooth and snowy white, and it turns of a brownish yellow as soon as broken. It is known as the snowball, or horse-mushroom (*A. arvensis*).

On the subject of distinguishing poisonous species, Mr. Cooke says that there is no golden rule which will enable us to tell at a glance the good species from the bad. The only safe guide lies in mastering, one by one, the specific distinctions, and increasing the knowledge through experience, as a child learns to distinguish a filbert from an acorn, or a leaf of sorrel from one of white-clover. The characters of half a dozen good, esculent species, he says, may be learned as easily as the ploughboy learns to discriminate as many species of birds. He tells us, moreover, that it is not enough to avoid poisonous species, but that discretion should be used in preparing and eating good ones. They change so rapidly, that even the cultivated mushroom, if long kept, is unfit for use. Nor is it enough that they be of good species and fresh; but plenty of salt must be used in their preparation, to neutralize any deleterious property, and pepper and vinegar are also recommended as advantageous.

Encouraged by these statements, from so distinguished and reliable an authority, we venture to present the pictures and descriptions of three more of the most highly esteemed of the edible fungi, which are common in the United States.

The Parasol Agaric.—Of this esteemed mushroom, Cooke remarks that it is in high request in Italy and France, and is also eaten in Austria, Germany, Spain, and England. It is easily identified. It has a fleshy cap, ovate when young, then bell-shaped, and afterward expanded and blunt-pointed. The extreme forms are shown in Fig. 8. The cuticle is more or less brown, and torn into patches or scales, except over the apex, these scales separating toward the margin. Flesh, white. Gills unconnected with the stem, and fixed to a collar on the cap around its top. Ring, persistent, loose on the stem. Stem six or eight inches high, tapering upward from a pear-like bulb at the base, hollow, with a loose pith, whitish brown, but more or less variegated with small and close-pressed scales.

Fig. 8.—The Parasol Agaric (*Agaricus procerus*).

Whenever a mushroom on a long stalk, enlarged at the base, presents a dry cuticle, more or less scaly, is darker colored over the blunt apex, has a movable ring and white gills, it must be the parasol agaric, and may be eaten without fear.—Robinson.

Chantarelle (*Cantharellus cibarrius*). Of this species Cooke says: "It has a most charming and enticing appearance and odor. It is almost universally eaten in all countries where it is found, England excepted." Trattinnich says of it, "Not only this same fungus never did any one harm, but might even restore the dead."

When young, its stem is white and solid, but becomes hollow and yellow. It is tapering, and passes into the substance of the cap, which is of the same color. The cap is lobed and irregular in shape (Fig. 9); its margin, at first curling inward, becomes expanded and wavy. The gills, or veins, as they are called, in this species, are thick, crooked, not compact, running some way down the stalk. Flesh white, fibrous, dense, with a fruity odor. Color, yellow, like yelk of eggs;

deeper on the under surface. When raw, it has the pungent taste of pepper. Spores, of a pallid, ochre-color. It may be found from June to October.

Fairy-ring Champignon (*Marasmius oreades*). This delicious fungus (Fig. 10) grows in pastures in rings, or parts of rings, and may be known by the following characters: Cap smooth, fleshy, convex, rather blunt at apex, more or less compressed, tough, leathery, elastic, wrinkled; when water-soaked, brown; when dry, buff, or cream-color, the apex often remaining red-brown, as if scorched; gills free from the stem, distant, swelling out in the middle, the same color as the cap, but paler; stem equal, solid, twisted, very tough and fibrous, of a pale, silky-white color. This genus is much addicted to dead leaves. —Cooke.

Fig. 9.—Chantarelle (*Cantharellus cibarrius*).

Another very acrid species (*A. urens*) has a similar appearance, but the gills are narrow and much crowded.

While all fungi are cellular in structure, they yet present a great variety of consistence. Some assume a corky or leathery firmness, while the substance of others is a mere watery pulp or gelatinous scum. Some are interlacing fibres, spread like a veil over decaying matters, while others are hard and tough like wood. They vary equally in taste and form. The cultivation of fungi for esculent purposes is confined to a single species, *A. campestris*, although, according to Cooke, there is no reason why others, for instance, *Marasmius oreades*, and the morel (*see* plate), should not succeed equally well. An unaccountable circumstance in this culture is the impossibility of growing mushrooms from spores. It is the mycelium or spawn which is always planted by gardeners, from which the production of mushrooms is simple enough, but how to obtain mycelium from spores is still a mystery. Other species present a similar difficulty, as the following statement from "Fungi and their Uses" will illustrate:

"A friend of ours, some years since, was fortunate enough to have one or two specimens of the large puff-ball (*Lycoperdon giganteum*) growing in his

garden. Knowing its value, and being particularly fond of it when fried for breakfast, he was anxious to secure its permanence. The spot on which the specimens appeared was marked off and guarded, so that it was never desecrated by the spade, and the soil remained consequently undisturbed. So long as he resided on the premises, he counted upon and gathered several specimens of the puff-ball, the mycelium continuing to produce them year after year. Burying a ripe specimen in similar soil, and watering the ground with an infusion of fresh specimens, has been tried without success."

FIG. 10.—FAIRY-RING CHAMPIGNON (*Marasmius oreades*).

Mushroom-growing, as carried on in some parts of France, is so extraordinary as to deserve mention. In the vicinity of Paris there are extensive caves formed by stone-quarries long since abandoned. In these caves, sixty or seventy feet underground, and extending great distances, the temperature is equal and the air moist, and here mushroom-beds are made, and immense quantities of the plant are grown for home and foreign markets. An idea of the magnitude of the business may be formed when it is known that one proprietor has twenty-one miles of beds, another sixteen, another seven, and so on through a long list. In the ramifications of the cave of Montrouge (Fig. 11), just outside the fortifications of Paris, there are six or seven miles' run of mushroom-beds. It is entered through a circular opening, like the mouth of a well, and the only mode of descent is down a shaky pole, furnished with cross-bars, the base of which rests in darkness sixty feet below.

A gentleman who visited this cave remarks:

"I had an idea that one might enter sideways in a more agreeable manner, but it was not so. Down the shaky pole my guide creeps, I follow, and soon reach the bottom, from which little passages radiate. A few little lamps, fixed on pointed sticks, are placed below, and, arming ourselves with one each, we slowly commence exploring dark, still, tortuous passages. . . . On each hand are little narrow beds of half-decomposed stable-manure running along the wall, that have not yet been spawned. . . . Wherever the rocky subway became as large as a small bedroom, two or three little beds were placed parallel to each other. They are about twenty inches high, and were dotted all over with mush-

rooms no bigger than peas. . . . Every thing looks quite neat, not a particle of litter being met with."

Of the way mushrooms are usually cultivated, and the various modes of cooking them, it is not our purpose to speak. Whoever

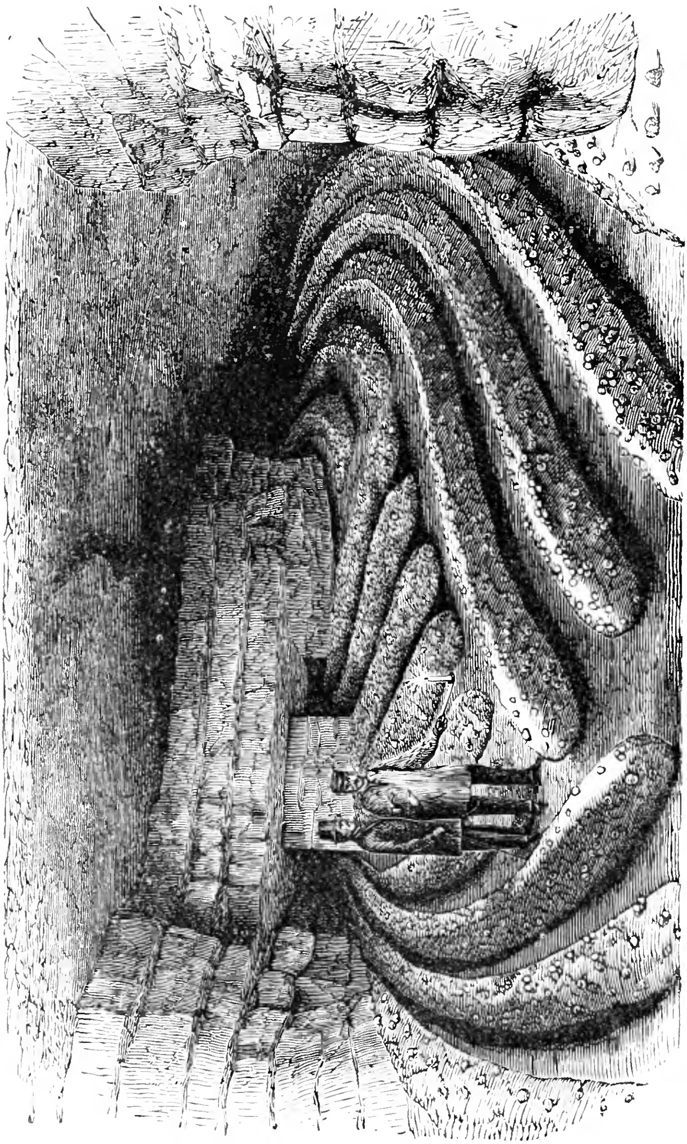

Fig. 11.—Mushroom Cave, Seventy Feet beneath the Surface, at Montrouge, near Paris.

wishes to study these subjects will find them fully treated in Robinson's "Mushroom Culture." To give an idea of the rich stores of

mushrooms in this country, we quote from a communication of the late Dr. Curtis, of South Carolina, in reply to inquiries of Rev. C. Berkeley:

"My experience with eatable mushrooms runs back only ten or twelve years. As I had grown up with the common prejudices against them, and had no lack of wholesome food, I had passed middle life before having once tasted a mushroom." Under the guidance of Mr. Berkeley he became interested in them, and overcame his timidity, and, at the time of writing, he adds: "I can safely say that I have eaten a greater variety of mushrooms than any one on the American Continent." After describing his mode of experimenting, and the various species he had proved, he continues: "I have collected and eaten forty species found within two miles of my house. There are some others within this limit which I have not yet eaten. In the catalogue of the plants of North Carolina you will notice that I have indicated 111 species of edible fungi known to inhabit this State. I have no doubt there are forty or fifty more, as the Alpine portion of the State, which is very extensive and varied, has been very little explored in search of fungi.

"In 1866, while on the Cumberland Mountains in Tennessee, a plateau less than 1,000 feet above the valleys below, although having very little leisure for examination during the twö days spent there, I counted eighteen edible fungi. Of the four or five species which I collected there for the table, all who partook of them, none of whom had before eaten mushrooms, most emphatically declared them delicious. On my return homeward, while stopping for a few hours at a station in Virginia, I gathered eight good species within a few hundred yards of the depot. And so it seems to be throughout the country. Hill and plain, mountain and valley, woods, fields, and pastures, swarm with a profusion of good, nutritious fungi, which are allowed to decay where they spring up, because people do not know how, or are afraid, to use them.

"I have known no instance of mushroom-poisoning in this country, except where the victims rashly ventured upon the experiment without knowing one species from another. There are families in America who have brought with them from Europe the habit of eating mushrooms, but I have not met with any whose knowledge of them extended beyond the common species, called pink-gills, in this country. Several such families live near me, but not one of them was aware, until I informed them, that there are other edible kinds. When I first sent my son with a fine basket of imperials to an intelligent physician, who was extravagantly fond of the common mushroom, the lad was greeted with the indignant exclamation: 'Boy, I wouldn't eat one of those things to save your father's head!" When told that they were eaten at my table, he accepted them, ate them, and has eaten many a one since with all safety, and with no little relish."

Among our best and standard mushrooms, Dr. Curtis mentions the meadow, the horse, and umbrella mushrooms, but adds:

"Tastes differ on these things as on fruits and vegetables; some putting one, some another, at the head of the list, though fond of all, and ever ready to use any of them, as one who prefers a peach may yet relish an apple. There are some among us who regard the umbrella-mushroom as fully equal to the meadow-mushroom, and I am of the same opinion. When boiled or fried, it truly makes a luscious morsel. I mention, in this connection, that this species here bears the name of nut-mushroom, from a quality that I do not find mentioned in the books

which describe it. The stem, when fresh and young, has a sweet, nutty flavor, very similar to that of the hazel-nut. Its flavor is so agreeable, that I am fond of chewing the fresh stems. From this peculiarity, in connection with its movable ring, its form and colors, I deem it a perfectly safe species to recommend for collecting."

Dr. Curtis says, however, that the same species varies very much in flavor in different regions, owing probably to differences of soil, exposure, shade, moisture, or temperature. He has found perfectly sound pink-gills with unpleasant odor and taste, and horse-mushrooms that were "perfectly detestable." But, whether such exceptional specimens are poisonous or not, he thinks of no consequence, because no human being could be induced to swallow them.

# ARE LANGUAGES INSTITUTIONS?

By W. D. WHITNEY,
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WHILE the present century has witnessed a truly wonderful advance in the study of languages, it has not yet yielded equal results for the science of language. Comparative philology has thus far borne off the palm over linguistics. The classifications of human speech, the historical development and divarication of languages, the processes of phonetic change, are understood to a degree of which our fathers had no conception; but the coördination and explanation of all these facts, the recognition of the forces whose workings underlie and produce them, and of the ways in which those forces act—on such subjects there is far from being that general agreement of opinion which ought to mark a matured branch of study.

To quote a few instances: while the Boppian view of the making of grammatical forms by collocation, combination, and integration of originally independent elements, may be regarded as the leading and orthodox one in the modern school of philology, there yet are scholars of rank who deny it, and assert, instead, that endings were created in their separate entity and office along with the bases to which they are attached, or sprouted out from the latter by the working of some mysterious internal force. Most linguistic scholars hold that the development of a grammatical system has been a work of ages, always going on and never finished; but at least one celebrated and admired authority declares the whole essential structure of a language to be produced "at a single stroke." It is the prevailing belief that the world is filled everywhere with families of related dialects, and that a family of languages, as of individuals or of races, arises by the dis-

persion and differentiation of a unitary stock. One or two teachers of the highest popular repute ask us to believe, instead, that language had its beginning in a condition of indefinite dialectic division, and has been always tending toward unity—that there are, as an exception, two or three real families, and no more, these being the result of peculiar and unexplained processes of arbitrary concentration in the remote past; and another bold doubter makes a great stir by denying the ordinary family-tree theory of linguistic kinship, and putting in its place a theory of wave-motion, propagated from a centre. Some hold (more or less consistently) that language is a natural organism, growing by its own forces and its own laws, with which men cannot interfere: others declare it an instrumentality, produced in every item by the men themselves who use it. Some write of it as a human faculty or capacity, like sight or hearing, as a gift, as identical with thought or reason, as the one distinguishing quality of man. Others regard it as one of the outcomes of a variety of faculties and impulses, by all of which man is far removed from the lower animals; as one which, under normal conditions, is sure to show itself, but which may, by the mere force of external and accidental circumstances, be thwarted, without impeachment of man's nature, but only of his education. Some maintain that the child learns his own language; others strenuously deny that there is any teaching or learning about it. Some, once more, declare the study in which they are engaged a physical science, while to others it seems as truly an historical or moral science as any other branch of the history of man and his works.

Now, with regard to all these matters of discordant opinion, only one side can possibly be in the right. We may be able to excuse those who take the wrong side, seeing where they are misled by looking at the facts from a false point of view, by misconceiving the meaning of a term or forgetting its double application, by omitting to take into account some decisive consideration, by overlooking important items of evidence, and so on; but wrong they are, nevertheless. And it is truly unfortunate that, just upon points of the most fundamental importance, the linguists should be so at variance with one another. Surely the study of language, so extolled on all sides for the strictness of its methods and the solidity of its results, might have gone so far by this time that its votaries should be able to give a nearly unanimous opinion, for example, as to what a word is in relation to a conception, and to follow that opinion logically and consistently out to its consequences. One grand reason for the discordance has been, to be sure, that linguists were so busy with the infinite and urgent details of their work: details which they have not yet begun to exhaust—hardly, even for the majority of human languages, to look over and get well in hand.

Germany is the home of philological and linguistic study; but the Germans are rather exceptionally careless of what we may call the

questions of linguistic philosophy, or are loose and inconsistent in their views of such questions; hardly seeming, in many cases, to be aware that there are antagonistic doctrines before them, one of which ought to be, and must finally be adopted, to the exclusion of the other. There needs to be, perhaps, a radical stirring-up of the subject, a ventilation of a somewhat breezy, even gusty, order, which shall make words fly high, and dash noisily against one another, before agreement shall be reached. If so, the sooner it is brought on, in whatever way, the better; and they are no true promoters of the progress of the science who strive to smooth things over on the surface, and act as if all were serene and accordant below.

Amid manifold minor diversities, and half-views and compromises innumerable, opinions respecting language seem to be divisible into two principal opposing classes, which may be termed (rudely, and without intended offense to the sensibilities of the adherents of either) the positive and the sentimental, or the common-sense and the metaphysical. The latter class tends toward an admiring contemplation of language, in its comprehensive relation to the human mind and human progress, and toward its study in and through the processes of mental action that underlie its production and use. The other class plants itself upon the consideration, first of details, and then of their combined result; it begins with the audible sign—the word—and works from this toward the intellectual process which it represents. The one strives after profundity, brings in its illustrations from remote periods and languages, and forms grand and striking views; the other aims at simplicity, at general intelligibility, at moderation, and rejoices in the overthrow of exaggerated and illusory opinions. It is by no means easy to characterize the two opposing tendencies fairly in a sentence or two; and I would not at all claim that the description here given is not tinged with the prejudices of the describer. One may acknowledge the influence of such prejudices in drawing up a general account of the questions at issue, while yet he may believe himself capable of examining and discussing, with entire fairness, any detailed views, any distinct statements or arguments, brought forward by the opposing party.

As to which of these two general tendencies is at present the prevailing one among the professional students of language, there can be no reasonable doubt: it is the one here called the sentimental or metaphysical. How long this is going to be the case is another and a more difficult question. In the prevailing confusion of discordant opinions, and carelessness about the discordance, described above, comparatively few have declared themselves; and there is probably light enough abroad to bring out men's decisions prevailingly on the right side when once they can be led to reason themselves into clearness and consistency of opinions. Meanwhile, the unlearned popular view of speech, that of the general body of cultivated people, that

which has most votaries among the students of physical science, and those who approach the subject from the side of general anthropology, is rather of the opposite type. That the division bears this aspect ought, it should seem, to tell against the latter doctrine; but there is no good ground for regarding the fact as decisive, for, until the linguists are agreed among themselves as to fundamental points, they have no common vote to throw.

For myself, I hold the more popular doctrine to be also the truer, and, in the proper sense, more philosophical; and the other to be founded on the insecure basis of combined misapprehension and exaggeration. And I propose to give here, in as brief a form as it is possible, my reasons for thus holding.

Every thing in the study of language, as in most other studies, depends upon the way in which one approaches the fundamental questions. In my opinion there is no other way here so secure and so fruitful as that of inquiring what our own speech is to us, and why; how we came by it, and by what tenure we hold it. The general linguistic philosophy we profess must, first and above all things, be consistent with the most accessible facts of present living language; we may not be able to explain these from themselves alone, but our doctrines must at any rate not go counter to them. If physical science has been worth any thing for its influence upon other sciences, it has been by inculcating its method of investigation, to make the utmost of what is immediately under our eyes, and reason cautiously back from the present into the past.

Nor, in getting at language from this side, must we undertake to deal with it as a body or total, lest we lose ourselves in glittering and indefinite generalities. We must take up only so much as we can hold in the hand, as it were, and deal with competently. Let us try the single word *book*. It is to us the sign of a very complex conception, but one which needs no defining. How came we by it? Every other linguistic community in the world that has the thing has also a name for it, but the names are all different—*livre*, *libro*, *buch*, *biblion*, *kniga*, *kitâb*, *pustaka*, and so on—let us say a round hundred of them. Why do we use for our conception this one of the hundred? There is but one answer to this, a common-sense answer, which no philosophy can possibly reason away. We learned the word, hearing it used during the period when we were engaged in learning things and their names, used over and over again, and in such connections as showed us what it meant; we learned to reproduce the series of sounds, and to associate it with the conception, just as we could have learned to reproduce and associate any other of the hundred, or any one of a thousand other signs—as a motion of the hand, or a square mark. There is absolutely no tie of union to us between the sign and the thing signified save this mental association, artificially formed—that is to say, brought about under the guidance of others, after their

example, not by any inward impulse. Some of us, indeed, know that the word has a curious history—that it is akin to *beech*, and for the reason that beechen staves or tablets were the first material used by our rude ancestors for cutting runes upon. But this is merely a matter of learned curiosity; our knowledge or want of knowledge, our belief or disbelief in the explanation when given us, has nothing to do with our use of the term *book;* we use it because others—those with whom it is our lot to have to do in life—also use it, because we can communicate with them by means of it. If we, though of English blood, had happened to be born at Paris, at Rome, at Cairo, at Peking, we should either have learned to use a different word from this, or another besides it, in the same sense and for the same reason—even as in English-speaking communities, especially in America, descendants of half the races under heaven use *book* as their "native" sign, knowing absolutely nothing of any other.

But what is thus true of *book* is true also of every other sign of which our language is composed, unless we may have committed in a few instances that rare act, the coining of a word. And this is already of itself enough to show that in a perfectly proper—indeed, in the only genuine—sense, our words are arbitrary and conventional signs: arbitrary, not because no reason can be given for the assignment of each word to its use, but because the reason is only an historical, not a necessary one, and because any other of the hundred current, or of the ten thousand possible, signs might have been made by us to answer precisely the same purpose; conventional, not because it was voted in a convention (what that we call "conventional" ever was so?), nor because men came to an explicit understanding about it in any other way, but because its adoption by us had its ground in the consenting usage of our community. There is no way of denying these two epithets to language, except by misunderstanding their meaning.

Moreover, it is not the case that the learner gives birth first to an independent and adequate conception of a book, and then merely accepts from others the name by which he shall call it. For the "inner form," not less than for the outer sign, he is dependent on his teachers. He would not, indeed, even begin to use the word if he had not formed some sort of an idea of a thing which it stood for; but he knows next to nothing about the thing; it is to him a mystery of which he only later obtains the key, and which he does not fully understand till after he has studied the history of civilization, a whole chapter of which is, in a manner, epitomized in the single term. And all this is given him in measure, as he is prepared to receive it, by the teaching of others. A further example or two will show this dependence still more clearly. The idea of *planet* came down to us as defined and named by our instructors, the Greeks, and named from the most superficially obvious property of the objects designated, that of "wandering," or moving amid the other stars. No uninstructed

person would single out a class of heavenly bodies to call by such a name; many races have never formed the conception. To those who gained learning enough, the meaning was further enriched by connection with the Ptolemaic system of cycles and epicycles. Then, as by a touch, Copernicus altered the whole aspect of the word, and changed the classification which it represented, ejecting the sun and moon, and taking in the earth. And all this is now used to help give shape to the at first dim and formless idea, which the language-learner is made to entertain along with the sign which is taught him. Once more, the child is made to count, and in the process his conceptions of number are cast into a decimal shape, one in which each higher factor is made up of ten of the next lower, till he comes to feel that such tenfoldness is a natural characteristic of enumeration. Yet, if we inquire whence comes this particular shape, we find it growing out of the simple fact that we have two hands, with five fingers on each! So utterly extraneous and accidental a cause as this, as turned to account by the simple races who laid the deep foundations of our mathematics, determines the "inner form" assumed by the mathematical conceptions of each new member of our race; of course, quite without his knowledge.

So it is all the way through language. Along with and by means of words, the young learner is made to take in the ideas which the knowledge and experience of older men have shaped; he accepts the current classifications and abstractions of his community, at first only imperfectly, then with fuller and more independent action of his own, till finally he grows up to the stature of his language, and has, at least in some departments, nothing more to learn of those about him. At the beginning, and in less degree later, he was so hurried on by the superiority of his instructors in knowledge and mental development, that he had neither leisure nor inclination to be original; now he becomes in his turn a teacher, and also a shaper. By his action and that of his fellows, the common instrument of expression undergoes a constant slow change. Their new knowledge has somehow to be worked in. It is done partly, as in the case of *planet*, by reshaping the conceptions contained in old words, and shifting the boundaries of old classifications; partly by the cognition of new particulars which are brought under old names, expanding so far their contents—as when Uranus and Neptune are brought into the class of *planets*, and the satellites of Jupiter and Saturn make a class for the formerly unique appellation *moon;* and partly by providing new names for objects, products, qualities, relations, before unperceived, or so dimly apprehended as not to seem to call for expression. And the provision is made in part by deliberately going to other tongues and borrowing material from them (so *Uranus*, *Neptune*), or else by forming new compounds of native material (so *steamboat*, *railroad*), or, very frequently, by mere transfer of old words to new uses, substituted or ad-

ditional. By these and other similar means, language is continually adapted by its speakers to express the modified content of their minds. At the same time, it suffers change of a yet more intimate and unconscious kind as an instrument; its phonetic shape being rendered more manageable, and its grammatical shape as well; new words of relation are made, by the attenuation of more material elements, and now and then, in a kindred way, a new form.

So far as a language is handed down from generation to generation by the process of teaching and learning, it is stable, and by this means it does remain nearly the same; so far as it is altered by the consenting action of its users, it is unstable, and it does in fact change. Examine any language, and you will find it different from its predecessor; different in a variety of items of the kinds instanced above, each of them being obviously the work of the speakers, and showing no signs of the presence of any other force. In the present stage of what we call the growth of language, nothing takes place which is not the effect of human agency; the only obscurity about it grows out of the fact that there is involved the consenting action of a community, since language is a social institution, and exists primarily and consciously for the purpose of communication. But if this is so nowadays, then it was so in the period next preceding, and in the one before that; and so on, until the very beginning is reached. For we have no right to assume unnecessarily that the processes of growth have essentially changed; that is to say, if the methods of word-making and form-making as exhibited in the historical period are sufficient to account for the whole existing material of speech, we are not authorized to postulate others.

And such is the case. Forms have been made, through all the historical periods, by the combination of independent elements, and the reduction of one of them to a formal value by means of changes of form and changes of meaning, such as are exhibited in every part of language; and this action, varying in kind and degree under the changing circumstances of developing speech, can never, so far as at present appears, be proved insufficient to explain the structure of language. If there are problems of structure as yet unsolved, they may be expected to yield to more skilled investigation; or, if they do not, it will be presumably because of the loss of needed evidence. The name-making process implies only the christening of a formed idea, the provision of a sign which shall henceforth be associated with a particular conception, and used to represent it in social intercourse and in the operations of thought. And the sign is obtained just where it can be most conveniently found, according to the circumstances and habits of each particular community. There is nothing approaching to necessity in an etymology. It is only a tie of convenience that connects the new name with its source: in the case of *book*, the tie of historical development out of an accidental selection of material; in

*planet*, that of intended, but palpably insufficient description; in *Uranus* and *Neptune*, of learned and reflective selection, under government of the same regard for analogy which controls also the most unconscious and popular choice of appellations; and in *decimal*, no one has yet been skillful enough to find out what. But, known or unknown, sufficient or insufficient, learned or popular, it is all one, so far as regards the practical uses of speech; when once established in use, the name, from whencesoever derived, is good enough for its office. It were vain indeed to be particular about the source, when the use is going to depend, with each new learner, on an artificially-formed association alone.

Now, how should it enter into the mind of any one to regard words thus won, thus kept in life, thus liable to alterations of every kind in the mouths of their speakers, as any thing more than the instruments, the outward equipment, of thought? Thought is the action of the mind, in apprehending, comparing, inferring; every word is an act of the body, and of the body only; performed, indeed, as all the voluntary acts of the body are, under the direction of the mind, but no more the work of the mind than are crooks of a finger, or brandishings of an arm, or kicks with a foot. There is no more immediate connection of the apparatus of thought with the muscles of utterance than with those of facial expression or of gesture. Talking is just as much thought as dancing is; not one whit more. All the arguments used to show the impossibility of mind-work without speech are, so far as I can see, such as would also prove the impossibility of manual work without tools and machines, of mathematical work without written signs.

If it be asked how the mind comes to equip itself with this instrumentality, the answer is ready and easy: it does so under the impulse to communication. That language should owe its origin and maintenance to a cause so extraneous to the soul, and so superficial, is repugnant to the prejudices of many; yet I do not see how the truth of the doctrine can be successfully controverted. It is in accordance with all that we know of the history and present use of language, and, not less, with all that we know of the development of man's powers in other departments. Through all its existence, speech is primarily and above all a social possession, its unity made and preserved by mutual intelligibility, all its items and their changes requiring the adoption of a community before they become language at all. Those who, by isolation or physical defect, are cut off from communication with their fellows, do not speak, and have no inclination to speak. And, especially, communication is the only inducement to which every human being, at every grade of culture, is fully accessible. The great majority, even of speaking, civilized men, do not realize that language is any thing to them but a means of communication; and to ascribe to the uncultivated man a power to foresee that expression will furnish

his mind an instrument to work with, and be to the race an indispensable help forward in the career of improvement, is to do him a great deal more than justice. This is the way in which in general the powers of man have been drawn out and educated; the art of writing came, in like manner, from attempts at another kind of communication; machines came, one item after another, in the struggle of man to supply his physical needs. We are short-sighted beings, and never able to look more than one step ahead, but we have the power of putting each new step beyond its predecessor, and are surprised by-and-by to see how far we have come, how much we have attained that we had neither expected nor foreseen.

If these views as to language are true, then the marked analogies of languages with institutions are patent and undeniable. A language is a body of usages; it has its main occasion and usefulness in connection with the social life of a community; it is a constituent part of the civilization of its community, worked out, like the rest, by long-continued collision and friction between man and his circumstances, gradually accumulated by the contributions of each member of a race through successive generations, and handed down by a process of teaching and learning. Let a child of European parents be brought at birth into an Indian wigwam, and grow up among Indians only; and his life in all its parts will be Indian—his food, his occupations, his amusements, his knowledge, and his beliefs—and, along with the rest, his language also; while the African, for instance, born and bred in an American community, shows in all these same respects accordance with that particular class of Americans among whom his lot is cast. This by no means implies that there are no such things as race-differences of capacity and disposition, even as there are wide individual differences between members of the same race: the white man makes, perhaps, a somewhat peculiar kind of Indian, the African a peculiar kind of American; yet each acquires the civilization, language included, of the race with which he grows up, and shows his race-characteristics, as they their individual characteristics, inside of that.

All names are imperfect, and have their unsuitable, as well as their suitable suggestiveness in connection with every new object to which they are applied; but I hold, and with the utmost confidence, that there is no general name so truly descriptive of a language as *institution*—none which takes into account so many of its essential characteristics, or marks so distinctly its place among the possessions of its community. The word, no doubt, offends some, and seems to others derogatory to the dignity of its subject; but I believe that the more the real nature and office of language are understood, and the more established and consistent the linguistic views of the educated become, the more its truth will be acknowledged. I have used it often, partly in a kind of defiance to those views which are decidedly

opposed to what it implies; I shall be ready to abandon it when its impropriety is proved by fact and argument.

The great obstacle, as it seems to me, to the prevalence of consistent and correct views concerning language, is the ambiguity of the word *language* itself. It means two entirely different things: a capacity, and a product of the exercise of that capacity. Language in the former sense—that is, a power to express thought by means of signs, and to develop this instrumentality into a great and intricate and wonderful institution, having the most important bearings on the progress of the individual and of the race—is a gift, a quality, a part of human nature, and all that; but this power does not give a single human being *his* language: it does not issue in any thing except through an historical development, by a gradual accumulation of the results of its exercise. It makes every human being capable of learning and using any language. It implies also that every human being is capable of producing a language—only let circumstances be sufficiently favorable, and give him time enough: say a few hundreds or thousands of ordinary lives. But the English language, for instance, or any other, is not such a capacity: it is the concrete accumulated product of the efforts at expression of the English-speaking or other community and its ancestors, continued through thousands of years. Each such product has its history: that is to say, it has been wrought only in time, and under the infinitely varied modifying influence of historical circumstances; each is different, therefore, from all the rest: a thousand different products, of every degree of diversity, but each one answering the same general purpose, and capable of being acquired and wielded by every normally constituted human being, of whatever race.

An additional obstacle, of another character, is the (of course, unconscious) craving of many people after lofty and poetic general views, views of which the very conception shall seem to exalt them. The doctrines set forth above are in many respects iconoclastic, and therefore repellent to them. They want to regard man's acquisitions as direct gifts to him from his Maker, or as spontaneous outbursts of his noble nature. M. Renan says ("Origine du Langage," chap. iii.), "Languages have come forth completely formed from the very mould of the human spirit, like Minerva from the head of Jupiter." Precisely so, we might answer; the comparison has a more complete applicability than even the eloquent author imagined; the one thing has the same kind of truth as the other; each is a beautiful myth, and it is hard to see why he who seriously accepted the former should not accept the latter also. For one man, we have taken all the poetry out of life when we have made him see that it is not his God, rolling on mighty chariots through the sky, and hurling thunder-bolts at the demons, but mere prosaic meteorological forces, that cause the thunder-storm; we have perhaps robbed another of both religion and self-

respect when we show him the earth gradually cooling and condensing, clothing itself with vegetable and animal life; and man himself creeping up through the ages from a condition of savagery, gradually finding out his powers by their exercise, laying up and shaping institutions—language among the rest—for traditional transmission, the knowledge and wisdom which are one day to raise him to the headship of Nature. We are all loath to put a truth regarded as humble in place of a brilliant error; and slow to realize that, when the false coloring is taken off, what remains is worth more to us than what we thought we had before.

There is, it is believed, a wide-spread impression that views of language of the kind advocated in this paper are "superficial;" and that only those treat the subject profoundly who lift it up either into the sphere of psychology, or on to the platform of the physical sciences, making linguistic study a department of the study of mind, or else of that of human organs and their functions. But that is a matter to be settled along with the truth or error of the views in question. If they are true, then those are superficial who, in a mistaken endeavor after profundity, abandon the true basis and method of their science. There are infinite mysteries involved in every act of language-making and language-using, with which the linguistic scholar, as such, has to do only secondarily, or not at all. To recur to our former example: the psychological processes whereby the rude conception of a *book* is formed, partly under instruction, and gradually developed into fullness and accuracy, are one subject of study; the physiological processes whereby one hears the word *book*, and then is able to reproduce it, by an imitative effort of his own organs, is another; the history of the civilization which has given birth to such product, and of the arts by which it is manufactured, is yet another; and there are more, clustering about the same word: with the great problems of existence and human destiny looming up in the background, as they do behind every thing that we attempt to investigate. But no one of these is the standing-point of the linguist; to him, the central fact is that there exists one audible sign *book*, representing in a certain community a certain conception, for all purposes of communication; used by hosts of people who know nothing about the history of books, nor about the operations of the organs of speech, nor about the analysis of mental processes—and answering their purposes as well as if they knew it all. The sign had a certain definite time, locality, and occasion of origin; it was applied to its purpose for reasons which lay neither in men's mental nor in their physical nature, but in their historical conditions; it has passed through certain changes of form and office on its way to our use. Here, now, is where the linguist takes his stand; from this point of view every thing falls into its true position of relative prominence. Language is a body, not of thoughts, nor of physical acts, but of physically apprehensible signs for thought; and the student of lan-

guage begins his work upon the signs, their office, and their history. Between him and the students of the other branches named there is a relation of mutual helpfulness. The history of words and the history of things cast constant and valued light upon one another. The sounds of language illustrate the articulate capacity of the organs of utterance, and their changes require for explanation a knowledge of phonetic science, as a special department of physiology and acoustics combined. And the contributions of language to psychology greatly outweigh in value those of psychology to the science of language, since the latter is the key to the historical development of human thought; and since words are not the immediate product of processes of cognition, or abstraction, or induction, but only the result of voluntary attempts to communicate those products. Most students of language, probably, believe all this, and act in their studies upon the belief; only they are too uncertain of their ground not to be often driven from it by the imposing claims of outsiders.

About eight years ago (in the autumn of 1867), I put forth a connected and carefully-reasoned exhibition of my linguistic views, in a volume entitled "Language, and the Study of Language;" in it I dealt only sparingly in controversial discussions of others' opinions, but left my own to recommend themselves by their concinnity, their accordance with familiar facts, and their power to solve the various problems which the science presents. Of the reception accorded to that volume I have no right to complain, and certainly I never have complained. But I have, at about that time and since, repeatedly taken occasion to examine narrowly and criticise freely the opposing views of others, and the arguments by which these were supported. And I have done it especially in the case of men of eminence and celebrity, men to whom the public are accustomed to look for guidance on this class of subjects. This, surely, was neither unnatural nor improper. What Smith, Brown, and Robinson, may say about language before ears that heed them not, is of the smallest consequence; but if Schleicher and Steinthal, Renan and Müller, are teaching what appears to me to be error, and sustaining it by untenable arguments, I am not only authorized, but called upon, to refute them, if I can. The last of the gentlemen just named, however, in his paper in the *Contemporary Review* for January last (p. 312, *et seq.*), even while very flatteringly intimating that my habit of criticising only the most worthy of notice is appreciated, and hence that those criticised feel in a certain way complimented by it, appears to think that their greatness ought to shield them from such attacks. I have very little fear that the general opinion of scholars will sustain him in this position. Each controversy is to be judged, rather, on its own intrinsic merits. If I have failed to make out a tolerable case against those whom I have criticised, then, be they great men or small, I have been guilty of presumption, and deserve reproof; if, on the contrary,

I have fairly sustained my views against theirs, I am justified; and on that basis I am perfectly willing to submit to judgment.

I do not think Prof. Müller the person best qualified to judge me fairly, because, in the first place, owing to his great fertility as a writer, and his position as accepted guide and philosopher, beyond any other living man, of the English-speaking people, I have felt called upon to controvert his views oftener than those of any other authority; and yet more, in the second place, because he does not appear to have qualified himself by carefully examining what I have written. He confesses to never having looked at my volume on language until a few weeks ago, when stirred up to it by the fact that my opinions had been quoted with approval in so conspicuous a quarter as the pages of the *Contemporary*. And, even now, he has evidently given it the most cursory examination. He has not observed that it was printed and published in England, instead of "in America." He has not discovered that it is a "systematic" discussion of its subject. He is mainly impressed, even to amusement, with its similarity to his own work: as, indeed, resemblances at first glance are always more striking than differences: if he will continue his study, he will certainly find the likeness less and less apparent, and extending almost only to those facts and principles which are universal property among philologists, neither he nor I having a patent-right to them; while the underlying differences of view and plan will become more and more conspicuous to him. And, most of all, he picks out and sets forth certain alleged inconsistencies in a manner which only great haste can explain and excuse, since every one of them would be removed by a consideration of the place and connection of each passage quoted. He is even more than once so unlucky as to select a passage as showing me to hold a certain view right out of an argument in favor of the contrary view. For example (p. 310), in citing my expression that the facts of language "are almost as little the work of man as is the form of his skull," he overlooks the preceding clauses of the same sentence: "So far as concerns the purposes for which he [the linguistic scholar] studies them, and the results he would derive from them." The whole being a part of a statement intended to show that "the absence of reflection and conscious intent takes away from the facts of language the subjective character that would otherwise *belong to them as products of voluntary action*." There are several other cases quite as palpable as this: it is useless to expose them here.

I ought to be more than satisfied with the insignificant array of trifling errors (or supposed errors) of detail in my volume, drawn up by Prof. Müller on page 312; unfortunately, I could myself, if called upon, furnish a much heavier list. I only notice one, as being an important evidence of the haste and cursoriness already referred to. My critic is shocked to find "the Phœnician alphabet still spoken of as

the *ultimate* source of the world's alphabets." Ultimate it certainly is, in the sense of being that alphabet from which the others derive themselves, in part through many intermediaries; the point in which they all centre: but if Mr. Müller had looked at the twelfth lecture, in which the Phœnician mode of writing is made the subject of more than a mere passing remark, he would have found its own derivative character most explicitly asserted and supported.

If Prof. Müller has not been willing to read until just now the work in which I had independently and connectedly put forth my own system of views, he has not, of course, been in a position to estimate fairly the critical articles in which I have had the avowed polemical intention of trying whether they could stand their ground and make head against the opposing views of other writers. It might naturally enough seem to him that I was too pugnacious. But I cannot help questioning whether he has ever read those articles also, or knows them in any other way than as he knows the one recently used in the pages of the *Contemporary* by Mr. Darwin: namely, in fragments and by the report of others. I am confident that he would not otherwise so misconceive their spirit, imagining that I am in the habit of making general depreciatory remarks about the scholars whose works I examine, and of casting hard words at them in place of arguments. He cites a little list of such words, which have caught his eye as he turned over my pages, and which he has conceived to be applied to himself. I cannot help quoting a passage in which—and, so far as I know, in which alone—two or three of them actually occur. After explaining my own views as to the origin of language at some length, I add (p. 434): "The view of language and of its origin which has been here set forth will, as I well know, be denounced by many as a low view: but the condemnation need not give us much concern. It is desirable to aim low, if thereby one hits the mark; better humble and true than *high-flown*, *pretentious*, and *false*." The words here underscored are those complained of by Prof. Müller: if they are applied to him, or to any one else, it must be by himself, not by me. Those to whom my works are really known will, I am sure, defend me against Mr. Müller's unfortunate misapprehension. I do not judge men, but views, and especially the arguments by which views are upheld. If I deem the latter insufficient or erroneous, I confess that I am apt to speak my mind about them too plainly. If one finds a whole argument founded on the assumption that two and two are five, it is, of course, the true way to say that "Sir Isaac Newton would not have reasoned thus; and, on the whole, it is safer for us to agree with Sir Isaac," rather than to declare the assumption false, and every thing built upon it unsound: yet, after all, if the latter is really true, and if the occasion for bringing out the truth is a sufficient one, and if the critic shows good faith, a desire to arrive at the truth and to treat his opponent with substantial justice, the shorter and blunter way is not

to be too utterly condemned. And, as I have said above, I am ready to be strictly judged by the truth or error of my criticisms.

The plainest of plain speaking is far less really injurious than misrepresentation and detraction under the mask of extreme courtesy. Surely, so much wholesale depreciation and imputation of unworthy motives can hardly be found in all my writings as Mr. Müller raises against me in this one article. I should not venture to accuse any one of being actuated in his literary work only by personal vanity and a lust for notoriety, except after the summing up of a long array of particulars and deductions—I think not, even then. If I declared any one to be noisy about a subject in inverse proportion to his examination of it, I should at least want to refer to examples that illustrated the peculiarity. Does my critic put these accusations forward as his example of how a controversy should be conducted in a gentlemanly manner? If I stated that any one "bitterly complained" that he was not answered by those he criticised, I should feel called upon to give chapter and verse for it; and neither Mr. Müller, nor any one else, can point out any such complaints on my part. I regard this as one more evidence of Mr. Müller's careless and insufficient examination of my writings. He got his wrong impression, I imagine, from an imputation which Steinthal brings against me. I did blame Steinthal for undertaking, in his chapter on the origin of language, to report and refute the opposing views only of the last-century theorists, as if there were no more recent opinions on the subject which had a claim to be considered; and he was pleased to interpret it as a reproach to him for not mentioning myself! I should think far worse of him and of Mr. Müller than I do, if I supposed them incapable, in their cooler moments, of understanding that a man may, without any improperly selfish feeling, be astonished, and even indignant, to see the views, which he holds in company with a great many others, quietly ignored; or that he may hold them so heartily that he shall feel called upon to stand forth in their defense whenever they are unjustifiably passed over, or are assailed with what seem to him unsound arguments.

My article upon Steinthal was so different from what Mr. Müller appears to assume it to be, when speaking of that scholar as having "retaliated with the same missiles with which he had been assailed," that I can only infer that it, too, is unknown to him except by false report. In a chapter of his recent work, "Abriss der Sprachwissenschaft," Prof. Steinthal seemed to me to have piled together about as many paradoxes as could well be gotten into so small a space, pushing the psychological method to an extreme which was almost its own refutation. To pick out a few points: for a definition of language, he gives us "it is what it is becoming"—he declares the divine origin of language inadmissible, because no science, save the philosophy of religion, has any right to take account of God; he holds primeval man—in distinction from the philosophers of the last century, who

wanted to degrade him—to have been a being of "creative force, from which religious and moral ideas flowed forth unsought;" his comparisons imply that language came into fully-developed being at once; he asserts the investigation of its origin to be "nothing else than this: to acquaint ourselves with the mental culture which immediately precedes the production of language, to comprehend a state of consciousness and certain relations of the same, conditions under which language must break forth," etc.; he denies that a child learns, or can be taught, to speak; he claims speech to be a capacity and activity like seeing and hearing; and he winds up with the conclusion that there is no such thing as an origin of language, except as it originates anew in every word we utter! Such views, expressed by one who stands so high in public estimation in Germany as Steinthal does, seemed to me to demand thorough examination. In my criticism, I went through the chapter, paragraph by paragraph, quoting in the author's own words nearly half of it, as I should estimate, and discussing in detail the various points made by him. Perhaps I carried on the discussion more vehemently than was necessary or desirable; I hold myself open to all due reprehension on that score; but that there were any personalities in it I utterly deny; it was an argument throughout, if a polemical one; it addressed itself only to the opinions it opposed, and the considerations by which these were supported. After nursing his wrath for two years, Steinthal came out in reply last summer with a volley of Billingsgate, pure and simple (Mr. Müller gives, p. 313, some choice examples of it); he enters into no argument, he makes no defense—unless it may be called a defense that he seems dimly to claim that, being only engaged in a preliminary laying out of his subject, he ought to have been indulged in putting forth any thing he pleased without being called to account for it—he tears his hair and splits into two persons with rage and disdain, and calls his assailant a villain and a fool. To such a tirade, there is but one answer possible; and to that I have no disposition to resort. Any one may judge from the specimens of Steinthal's views given above, whether they are so obscure from profundity that a man of less than extraordinary penetration cannot hope to understand them; *to me*, the only incomprehensible thing is, how a man of learning and acuteness should have arrived at them, and should have so little to say for them. I am perfectly willing to lay the *acta* of the controversy before the public just as they are—Steinthal's chapter, my criticism, and his retort, without a word further added in my own defense; and I should be confident of a general verdict in my favor.

Prof. Müller fears that I am generally becoming convinced that I am unanswerable. Perhaps every one runs that risk who, after what seems to him due examination and deliberation, has come to hold a certain set of opinions with great confidence, and who, with his best endeavors, does not find among opposing views and arguments any

that can overbear his own. One thing I am certain about: namely, that neither Müller nor Steinthal has answered me. As Mr. Müller appreciates so fully the danger in which I am placed, I wonder that he is not willing to put forth a hand to save me from it. I have with these gentlemen, so far as concerns my side, only a scientific controversy, sustaining my view of language against their contrary (and mutually conflicting) opinions. If I have been over-warm in assault, that is my disadvantage as well as my fault, as I thereby lay myself the more open to a counter-attack, having no right to claim to be treated more gently. But I have a right to protest against the controversy being made a personal instead of a scientific one; against being met with the plea that I am too disrespectful to the magnates of science for my arguments to deserve attention. Such a reply is generally, and justly, regarded as equivalent to a confession of weakness.

It has, perhaps, been my misfortune not to appreciate sufficiently the services rendered by Prof. Müller to the science of language; certainly, while fully acknowledging what he has done toward spreading a degree of knowledge of its facts, and, by his *prestige* and eloquence, attracting to them the attention of many who might have been reached in no other way, I might have been able to see that he helped either to broaden its foundations or to strengthen its superstructure. In ways and for reasons which I have sufficiently detailed in other places, his views have seemed to me wanting in solidity of basis, and in consistency and logical coherence. The difference between us is by no means of that slight character which, in his article, he gives it the air of being—"a slight matter of terminology," and the like; it reaches to the bottom. Holding as I do, I cannot expect that his proposed work on "Language as the True Barrier between Man and Beast," whatever its general interest and readableness, will be a contribution of serious importance to the discussion of the subject. Nor, indeed, that, by any one, more can be made of this barrier than has been made of the various others, which a profounder zoological and anthropological science has thrown down, claiming that no impassable barrier, but only an impracticable distance, separates the two—and separates them just as effectively. If my view of the nature of language is the true one, the absence of speech in the lower animals is easily seen to be correlated with many other deficiencies incident to their inferiority of endowment; they have no civilization, no "institutions" of any kind; nothing that goes down by tradition, is taught and learned. Their means of communication is almost wholly intuitive, not arbitrary and conventional, which are the most essential and highest attributes of ours. I say "almost," because I think the want not absolute; the rudiments of speech are just as much present in animals as, for example, those of the use of instruments; on account of which latter, Mr. Müller pronounces the "use of tools" no barrier.

Human language began when sign-making by instinct became sign-

making by intention; when, for example, an utterance of pain or pleasure, formerly forced out by immediate emotion, was repeated imitatively, no longer as a mere instinctive cry, but for the purpose of intimating to another, "I am (was, or shall be) suffering or glad;" when an angry growl, once the direct expression of passion, was reproduced to signify disapprobation or threatening, and so on; that is to say, when expression for personal relief was turned into expression for communication. The human intellect had the power to see what was gained by this means and to try it further; and it could follow on and on, in the same course, until a whole language of signs was the result. It cannot be successfully maintained that no animals are capable of taking even the earliest steps in this process; if a dog stands outside a door, and barks or scratches, to attract attention, and then waits for some one to come and let him in, that is, in all essential respects, an act of language-making; and the dog, and some other animals, can do much more than that. Here is the point to which the attention of naturalists should be directed, if they wish to determine how far the animals advance on the road to language; to what extent are they able to turn signs—utterance, or gesture, or posture, or grimace—to account for the purpose, and with the intention, of intimating meaning. To determine what definite natural cries they have is comparatively nothing to the purpose, since these are not the analogue of human speech; to put the inquiry on this ground, involves the capital error of attributing to the human voice a special relation to the apparatus of mental action, as its natural means of expression, instead of regarding utterance as merely that form of bodily activity which, on the whole, is most available for expression, and which, therefore, after due experience of its advantages, is most availed of by man. The real expressiveness of cries and exclamations lies, not in their articulate elements, their vowels and consonants (if they have any), but in their tones; and we keep these same tones as auxiliaries of the very highest value to our articulate speech, when we wish to impress and persuade.

Quite as much, I am sure, lies within the compass of the lower animals, in the way of intentional intimation of their wishes, as in the way of tool-using; and hence the former is no more a "barrier" than the latter. But the animals can go no further in the direction of developing their rude beginnings of expression into a language, than of working up their tools into a mechanical art, with all its appliances, simply because they have not the capacity; and in this capacity of indefinite development, by accumulating the results of the exercise of his powers out of a condition originally as low, or wellnigh as low, as that of the animals, lies the distinction of man—a distinction which ought to satisfy the most exacting lover of his species.

As regards "general ideas," of which Mr. Müller arrogates to himself and his followers the monopoly, I confess to being wholly of the opinion of Mr. Ellis: "Animals, to my mind, have concepts, with quite

as much right to be termed general, as any which I possess myself, the difference being one of degree." So long as Mr. Müller puts his exclusive claim solely on the ground that animals have no language, he must not expect to gain over many adherents. "Animals cannot talk, because they have no general ideas; they evidently have no general ideas, because they do not talk"—surely, as pretty a circle as ever was drawn with compasses; a mere duplication and bending around into a curved and reëntering form of the dogma that thought is impossible without words; that the intellect cannot apprehend resemblances and differences, cannot compare and infer, without the bodily organs to make signs for it. If this is an exaltation of the value of language, it is an equal degradation of the power of the mind.—*Contemporary Review.*

# THE CONSERVATIVE DESIGN OF ORGANIC DISEASE.

By Prof. A. F. A. KING, M. D.

If we should say that diseases prolong life, that without them man would be more liable than he is to sudden death, the announcement would be received by most medical thinkers, and by all those who have never studied pathology at all, as a transcendental idea, quite insusceptible of logical proof. But it is otherwise: that certain processes of disease are really conservative, and contribute to the longevity of the individual, is an absolute fact, as we shall now endeavor to demonstrate.

Let it be noted that almost from time immemorial physicians have recognized in the body a certain power of resisting injuries, and of returning spontaneously to health, when disordered; and this they have called the power of Nature—the *vis medicatrix naturæ.* The growth of this idea culminated, during the sixteenth century, in the establishment of the so-called "Stahlian system of medicine." And, while the doctrines of Stahl were sustained and elaborated by many of the leading physicians of his day,[1] we now know they were erroneous, for he maintained that there resided in the organism a "*rational soul*" which, he affirmed, not only formed the body, but excited and directed all of its motions; it was alleged to perceive intelligently the tendency of all external impressions acting upon the body, and to excite such motions as would favor the beneficial and obviate the injurious influence of such impressions. Hence, generally speaking, diseases were considered to be salutary efforts of the "presiding soul," and were to be

[1] By Perrault in France, Gaubius in Holland, Porterfield and Simpson in Scotland, Juncker in Germany, and by Nichols and Mead in England.

assisted, and not interrupted, by the interference of art; it was, however, admitted that the "rational soul," owing to surprise, fear, or despair, occasioned by too sudden or vehement impressions made upon it, would sometimes excite adverse motions which it was right to moderate.

Prevailing only for a season, the system of Stahl was finally abandoned as a visionary hypothesis; it was deprecated, as leading physicians to neglect the use of remedies; for its followers, trusting chiefly to the attention and wisdom of Nature, adopted the inactive mode of curing by expectation—*la médecine expectante*, as the French term it. The use of opium, cinchona, mercury, and other potent medicines, was zealously opposed by the Stahlian physicians, and they were extremely reserved also in the use of bleeding, emetics, and other evacuant remedies.[1]

Before we dismiss this part of the subject, it may be worth while to note, as illustrating the not uncommon cyclical revolution of opinion on scientific questions that are yet unsettled, that the medical practitioners of to-day—at least the best or most successful of them—have adopted the identical mode of practice for promoting which the doctrine of Stahl was allowed to fall into disrepute. Nowadays, like the Stahlians of old, we have laid aside bleeding and emetics, mercury and evacuants, and, content with feeding the patient and contributing to his comfort, wé leave the disease to take care of itself—we trust again to the *vis medicatrix naturæ*. The physician of to-day who should boast of *curing* a disease (unless, indeed, it were an ague, with quinine), would be considered, by his more highly-informed fellow-practitioners, as profoundly ignorant of the recent advances made in the science of pathology.

Another erroneous hypothesis, not differing very widely from the idea of Stahl, and which may be named and dismissed before we proceed, is that which supposes the existence, in the nervous system, of some tangible, central point of nerve-matter, from which, as from a seat of government, mandates are issued to control the motions and changes that take place in every quarter of the organism; and which leads us to infer that processes of disease, since, as it would seem, they are allowed to take place by this governing "central point," would be rather protective than suicidal to the individual. This view—never very widely acknowledged—received its final death-blow by the publication of Virchow's "Cellular Pathology," in which it was shown that the entire organism, in all its parts, is really composed of an indefinite number of individual centres, in fact cells, each of which has a life of its own, performs its own functions, and dies its own death: it is the invisible motions of these millions of microscopic entities,

[1] Stahl's principal work, in which his system was displayed in its most matured form, was entitled "Theoria Medica vera, Physiologiam et Pathologiam sistens." Printed at Halle, in 1708.

which, in the aggregate, constitute the visible changes and actions which we say characterize life. The anatomist has never discovered any "central point," nor the microscopist any "single cell," which governs the motions of the rest. Every supposed "central point" has been found, on microscopic examination, to split up into innumerable millions of centres, or individual cells. Moreover, in plants, in which the processes of life appear to be directed quite as intelligently as they do in animals, no trace of a nervous system has yet been demonstrated.

To many of my readers it would perhaps be a much more acceptable explanation of the (what seem to be) *intelligently*-directed processes going on in living bodies, than either of those already mentioned, to say that they must be ascribed to the rational will of a Creator urging an unconscious organism, by the laws he has ordained, to perform certain acts necessary to its preservation.

But, as the absolute scientists and those who religiously believe in a Creator are just now crossing swords, I will not press this third explanation, but rather choose to sustain the position I have assumed on the broader middle ground of natural philosophy.

To return, therefore, to the main proposition, namely, that organic diseases are naturally designed for, and do in fact accomplish, the prolongation of life, it will be observed that I have purposely omitted from consideration those other and more simple kinds of derangement which we call *functional diseases.* The conservative use of many of these latter has been universally recognized. The vomiting that occurs when poisons or indigestible matters have been introduced into the stomach, does good, by removing the offending substances. In like manner, the functional derangement of cough secures the expulsion of irritating gases or powders that have been inhaled, and of the accumulations of mucus that occur in every bronchial catarrh, and which would otherwise clog the tubes and induce suffocation. The watery diarrhœas that arise from indigestible articles having passed into the intestine, cure themselves by washing away the irritating materials, and the intelligent physician, instead of curbing the derangement, assists it with a laxative, and so helps Nature with the cure.

When, however, we come to speak of the more permanent *structural* changes, which neither Nature nor art can remove, and which have seemed to produce premature death, scarcely any one will acknowledge that the processes which develop them are at all conservative. Yet they are. And the error of supposing they are not has arisen chiefly from a total misunderstanding as to the *nature of disease.* A very prevalent idea, if not indeed a universal one, seems to be, that disease is a separately-existing entity—a thing independent of the body and inimical to it. We constantly hear, for example, of an individual being "attacked" with pneumonia; of an army "as-

sailed" with small-pox; of a city "assaulted" with cholera, and of its inhabitants being decimated by the "stealthy ravages" of consumption. Now, *so considered*, there is no such thing as disease. Who has ever seen it isolated from the body?—And when, in accordance with this view, we ask the question, "What *is* disease?" there is but one answer, namely: Disease is the tertiary product of two factors: 1. Of impressions or stimuli acting upon the body from without; and, 2. Of the reactions performed by the organism in response to the impression of such stimuli. The *tertium quid* following the action without, and the reaction within, is the thing "disease." Exactly in the same manner a stone thrown against a pane of glass makes a hole in it; yet, when we try to consider the hole as a separately-existing entity, we find it does not so exist. If it did, we might take away the pane of glass, and leave the hole by itself, but this is impossible. The aperture in the glass is a *tertium quid* resulting from two factors. viz., 1. The action of the stone from without; and, 2. The reaction of the glass when struck by the projected missile. Furthermore, it is evident that the *quality* of the resulting tertiary product can be made to vary indefinitely, either by varying the character of the action (i. e., by modifying the shape, size, direction, velocity, etc., of the stone), or by altering the reactive properties of the glass (i. e., by modifying its thickness, elasticity, inclination, etc.). Equally so the quality of disease will vary in different individuals in accordance with the variation in the quality of their reactive powers, as well as in conformity with the character of the actions by which the reactions are elicited.

Now, since the external stimuli which act upon the body in the manner we have described only produce their effect in *living organisms* (for in dead bodies and inorganic matter they do not elicit similar reactions), it is evident that the tertiary products which we call organic disease are purely the result of *vital processes*, and for this reason alone must be conservative, as are all the phenomena of life. Once dispute this and we should have to adopt the other alternative, that the organism would be better off if the reactive powers with which we find it to be endowed were annulled; and this conclusion would compel us to acknowledge the possibility of our thinking out an *improvement upon Nature*—a monstrous assumption, which no student of science will for a moment entertain.

In a condition of health the various processes going on in the body, which we call vital phenomena, are nothing more than a series of internal reactions provoked and maintained in obedience to the impression of surrounding conditions that act upon the organism from without. The reactive powers possessed by the healthy organism are perfectly natural to it, and, so long as the external stimuli impressing the body from without are also perfectly natural, the resulting *tertium quid* will simply consist of a naturally-constructed, a physiologically-developed organism. And if we now ask ourselves, "What is the use or design

of organs and structures that have thus followed a perfectly normal course?" we are soon able to discover that there exists between the developed organs and the external stimuli which provoked their development a mutual relation of such a kind that one is perfectly adapted to the other; in a perfectly natural state, physiological organisms are nicely adjusted to the external conditions surrounding them, in which it is natural for them to live, and which require of the organs developed just such functions as their formation and power adapt them to perform. *Adaptation of the organism to its environment* is, therefore, the grand purpose of the peculiarities of structure observed in different animals and plants. It is almost needless to present illustrations; they occur without number, and are quite apparent to the most superficial observer. The digestive organs are differently constructed in the herbivorous and carnivorous animals, and are thereby adapted to the different kinds of food on which the animals subsist. The gills of fish and the lungs of mammalian quadrupeds are structurally and functionally unlike; the differences adapting the breathing-apparatus of each animal to the particular kind of respiratory medium in which it is to live. And so of all other organs.

Now, if, instead of permitting the organism to remain living in its natural state, we change the surrounding natural conditions to others that are unnatural, the action of these latter will excite in the organism corresponding unnatural *re*actions: at first an unnatural modification of *function* will ensue; and in time, if the modified functions are in this manner continued, we observe a corresponding modification of *structure* to follow. But the modifications of structure, thus induced, are nothing else than *organic diseases;* they are departures from the physiological standard of health. And if we ask, "What is the conservative use and designed purpose of these unnatural deviations?" the answer is, that *the modifications of structure adapt the affected organs to modified functions that they have been called upon to perform, and mould the organism to new conditions that have been brought to act upon it;* just as variation in the physiological construction of different animals adapts them to the various differences of surrounding media in which they are designed to live. Pathology, therefore, is really nothing else than modified physiology. Physiological development is the evolution of organs and the growth of organisms under the impression of *natural* external conditions; pathological development is the evolution of organs and the growth of organisms under the impression of *un*natural external conditions. Adaptation of structure to function—of organisms to surrounding media—is the designed conservative purpose of both kinds of growth.

Furthermore, as no two human organisms are ever, in any particular, precisely similar, and as between organisms that have followed a strictly physiological development, and those whose development has been decidedly pathological, there are still others of intermediate

character, whose deviation from physiological and approach to pathological development have been less decided, or extremely slight, it is evident there exists between the two kinds of growths no well-defined line of demarkation; physiology and pathology run gradually into each other. It is not possible to say where one ends and the other begins. That this must be the true state of the case is unmistakable when we consider that the change of external conditions from natural to unnatural may be in any—the slightest or the most extreme—degree. Thus we frequently observe modifications of structure induced by exceptional conditions that have been brought to act upon the body, of so trivial a character that they can hardly be called diseases, while at the same time they are in some measure anomalous deviations from the typical standard of the species; but in these, as in the higher grades of structural modification, it will be seen that the conservative purpose of adaptation is carried out. For example, the muscles in the right arm of the blacksmith, those of the leg-calf in the limbs of the dancer, and the crural adductors of the jockey, undergo a process of increased growth (a physiological hypertrophy) by which they become adapted to the increase of function imposed on them. So the thickened epidermis of a laborer's palm adapts the hand—by protecting the softer tissues underneath from being bruised—to the rough handling of manual instruments; an adaptation altogether wanting in one unaccustomed to labor, as evidenced by the inflamed and blistered condition of his hands when first beginning to practise such exercises.[1] By the same kind of thickening and induration the finger-ends of the violinist become adapted to sustain without inconvenience prolonged pressure upon the strings of his instrument. When the main artery of a limb has been obstructed, or tied by the surgeon's ligature, we find the nutrition of the tissues beyond is supported by the blood finding its way through the smaller anastomosing arteries, and in time we observe these smaller arterial branches to become considerably enlarged, thus adapting themselves to the increased amount of blood they have been called upon to transmit. In cases where obstruction to the arterial circulation is more general, so that it requires an increased heart-force to pump the blood through its channels, we observe the heart itself to become larger, and thus its increase of structure (like the blacksmith's arm) is adapted to the required increase of function. The head of the thigh-bone, when irreducibly dislocated, becomes surrounded in its new position with fibro-ligamentous and muscular structures, which so far resemble an articulation as to permit the patient to walk about. Similarly in ununited fractures, we find the ends of the broken bone, when the muscles attached to them cause

[1] If it should here be alleged that the "inflammation" is the real disease, and that it accomplishes no good, we answer: Inflammation is the process by which the mechanical injury of contusion is to be repaired. It restores the part, just as the "adhesive inflammation" of surgeons heals up the cut of an incised wound.

the fragments to move one against the other, become covered with cartilage and encapsulated with fibrous and ligamentous tissues, so as to form the "false joint" of surgeons. Mucous membranes, when continuously exposed to the air, adapt themselves to their new situation by becoming covered with a layer of epidermis closely resembling skin. Of this we have a good illustration in long-standing cases of *procidentia uteri*, where the vaginal mucous membrane is often continuously exposed.

The vegetable world also furnishes numerous illustrations showing how plants adapt themselves, by modification of structure, to new conditions in which they have been placed. The geranium in our window, instead of growing in its naturally vertical direction, disposes its twigs and branches obliquely on one side, thereby adapting them, their leaves, blossoms, etc., the better to receive the rays of light that come in slanting through the window. Plants kept more or less in the dark, have a deficiency of color; they become bleached and white, but this lessened opacity of their skin, this increased transparency of tissue, enables them to make the most of what little sunshine is allotted them.

The sprouts of an onion or potato, when kept in a dark chamber, grow to an *unusual length*, and, although this elongation can accomplish no good when the bulb is packed in a barrel, or housed in a cellar, still it is evident that the plant is obeying the same laws of adaptive growth by which, when buried deeply in the earth, its sprouts increase in length until they reach the sunny surface of the soil.

Now, while these instances (and many others might be added) certainly furnish unequivocal evidence of a disposition on the part of organs and organisms to adapt themselves to new conditions in which they have been placed, and to altered functions they have been required to execute, yet it must be admitted they exhibit little or no proof that those other organic alterations, which we regard as fatal diseases, are imbued with the same conservative design. In fact, to meet the issue at once—to strangle the serpent before we take out his fangs—it is necessary to dispose of the objection that organic diseases, structural formations resulting from pathological development, produce physical pain, and lead to death; for that they do so is the common belief.

To meet this objection it is simply required to follow out the analogy, already alleged, between structures resulting from *physiological development* and those produced by *development that is pathological.* That the *causes* and *objects* of the two kinds of growths are the same, has been previously intimated. We proceed by calling attention to (what may surprise those who have not given the subject proper consideration) *the great fatality attending physiological evolution:*

Very young animals, and indeed young plants, are peculiarly liable to die before reaching maturity. This is especially the case in animals,

at least during the first few days of life, but the liability continues, though in a gradually-decreasing ratio, until physiological development is complete. Breeders of stock know very well the difficulty of rearing the young; and even in wild animals that live in a perfectly natural state, untrammeled by domestication, a good proportion of new-born individuals perish in early life. Gardeners and agriculturists drop more seeds in a place (of corn "in a hill," for instance) than they intend shall remain as plants, knowing that in the earlier stages of growth many of the "seedlings" will die; and, if more shall remain than is advisable, they are afterward "thinned" by hand. Surely every mother of a family knows the difficulty of rearing children, and our "bills of mortality" sufficiently attest the immense *fatality attending physiological development in the human family.*

Now, while in each of the instances I have cited the causes and mode of death are similar to or at least analogous with each other, it is only in the case of our own species that, generally speaking, we say death has been caused *by disease.* In the young chick, the wild animal, and the seedling plant, we are content to say they die because they are young, or "tender." The truth is, that death has been due, in each case, to *an arrest of, or interference with, the quite normal process of physiological development*, and to put this conception to a further test we may begin still a little earlier in life by studying embryonic development. In the case of oviparous animals, for example, we know many of the eggs never come to perfection; the young embryos they contain die during incubation. And while the pathologist, if he were to delve with his microscope into the secret physiology and pathology of the growing embryo, might find different membranes and organs fatally affected (congested or inflamed) according to the different stages of development at which the mortal disturbance took place, it would seem very odd, in case it should happen to be the rudimentary lungs of the growing embryo that were found specially congested, if he should say the egg had been "attacked" with pneumonia (inflammation of the lungs); or, if he should find the heart or intestines congested, how queer it would sound to say the egg had died from an attack of carditis (inflammation of the heart), or enteritis (inflammation of the intestines)! yet these so-called diseases are just as much causes of death in the egg as in the child after it is born.

The relevancy of the facts mentioned to the question at issue—the bearing of the argument—is this: organisms undergoing physiological evolution, and those in which pathological evolution is going on, are alike liable to be fatally affected by certain disturbing causes that interfere with the typical progress of development in each; hence the great mortality incident to childhood and early life is strictly analogous with the mortality attending organic diseases in the adult.

This analogy may now be further sustained by considering what these disturbing causes really are; and here I may premise they will

be found to be the same both in physiological and pathological development.

Most prominent among the conditions necessary to secure the normal progress of physiological development is *warmth;* and nothing more decidely interferes with it, or more quickly arrests it, than exposure to *cold.* In fact, an elevated temperature is the initial power—the first mover of the developmental process in all organisms, vegetable as well as animal. It is solar heat that forces the seed to germinate, the plant to bud, and the flower to bloom. Without warmth the fecundated egg of the oviparous animal would ever remain an inert mass; hence the snake deposits her germs in a dunghill of rotting vegetable matter where they may be warmed by the heat of fermentation. The ostrich intrusts her egg almost entirely to the sun-baked sand of the African desert; and birds in general incubate for days or weeks to supply the necessary heat for securing the development of their eggs. Fish inhabiting waters that are deep and cold, seek shallower and warmer streams in which to deposit their spawn. The difference between the warm and the cold seasons of the year, as regards the prevalence of reproduction, in both animals and plants, is familiar to every one.

But, besides heat being the *primum mobile* of normal evolution, it is equally necessary to maintain it when already begun. Exposure to cold is fatal. The shivering of young animals—their great liability to become chilled on exposure to a depressed temperature—has been observed by every one; and in the breeding of domestic animals, as in the cultivation of plants, there is probably no more potent source of mortality than insufficient warmth; and, further, this mortality is found to be more prevalent during unusually cold seasons. Now, the young of our own species form no exception to this rule; they, too, are liable to suffer a fatal arrest of physiological development on being exposed to cold. Thus, in a statistical inquiry as to the average number of deaths at different seasons, and at different ages, from a table prepared by M. Quetelet, of Brussels, it appears that, during the first month of infant life, the external temperature has a very marked influence; for the average mortality during each of the three summer months being 80, that of January is nearly 140, and the average of February and March 125. This is confirmed by the result obtained by MM. Villermé and Milne-Edwards in their researches on the mortality of the children conveyed to the foundling hospitals in the different towns in France; for they not only ascertained that the mortality is much the greatest during the first three months in the year, but also that it varies in different parts of the kingdom according to the relative *severity of the winter.*[1]

Additional proof of the disastrous influence of cold in early life, and, by-the-way, an explanation of the apparent natural defect in grow-

[1] *See* Carpenter's "Human Physiology," American edition of 1856, pp. 419, 420.

ing organisms implied by the existence of a liability to be fatally injured by it, may be found in the fact that Nature has amply provided for maintaining all very young animals at an elevated temperature, and protecting them from external cold. Note, first, how animals usually breed during the seasons of spring and summer; and observe, further, how the bird feathers her nest for the reception of her young, and shelters them under her wings, at the same time imparting heat by the contact of her own warm body. Rabbits and other animals tear off the fur from their own skins in order to provide a warm bed for the young while the parent is away in search of food. Frequently, too, animals are born in broods, or litters, especially those that are nearly nude at birth, and incapable of generating heat by exercise, and thus warmth is generated, or at least maintained, by the crowding together of a number of individuals in a small space.

Whether the liability, on the part of young animals, to be injuriously influenced by cold, is owing to their vital forces being so taken up with the process of growth as to leave a smaller surplus of vitality to resist the chemical agency of a diminished temperature, or whether it is that the lack of muscular exercise in them prevents the development of heat, we may not be able to determine; but this question is immaterial so far as the fact itself is concerned, that cold acts injuriously. It seems not improbable that the liability to be unusually affected by cold may depend upon *rapidity of organic change.* Thus those organs are most readily affected whose evolution is in most rapid progress; hence the digestive organs of the child and its pulmonary tissues are more apt to suffer from a depressed temperature than its reproductive organs; the former are undergoing rapid development, the latter are in a state of almost complete quiescence. Similarly the increased rate of tissue-change incident to violent activity of function appears to increase the susceptibility to cold; thus any one who has unusually exercised certain muscles will, after exposure, find those muscles become painful, "stiff," tender, and inflamed, while the remaining muscles of the body will have escaped any such manifestations. Buds that have withstood the severest cold of winter are often killed by the late but more moderate frosts of spring, because at this latter period they are in a state of more rapid tissue-change. The egg of the fowl will bear a considerable degree of cold without losing its vitality so long as its evolutionary processes are at a stand-still; but, when the rapid changes of structure incident to embryonic development have been set up, exposure even to the ordinary atmospheric temperature of spring and summer, if at all prolonged, is sufficient to destroy its life.

The greatest security against injury, therefore, from exposure to cold, would seem to be (comparative) *structural stability—organic rest.* But, in whatever manner to be explained, the fact remains that processes of physiological development may be disastrously embarrassed

by the want of a continuous sufficiently elevated temperature, and fatally injured by direct exposure to cold.

It now remains to show that organs undergoing *pathological* evolution (conservative structural modification) are affected exactly in the same manner by exposure to cold. Speaking, first, theoretically, we find organs thus circumstanced are the seat of an exalted rate of tissue-transformation, of a change additional to that which belongs to the ordinary process of waste and repair, and therefore we should *a priori* expect to find in them the same liability to inflammation, on exposure, as was observed in organs being rapidly developed physiologically. Speaking practically, we find, *a fortiori*, that this is actually the case. What is more common, with a patient who is the subject of some chronic organic disease, than to be suddenly cut off by the occurrence of acute inflammation in the affected organ after exposure to cold? Every medical practitioner can answer. In remarking upon the influence of cold as a cause of mortality, Dr. Carpenter, in his "Human Physiology,"[1] refers to the Report of the Registrar-General for March, 1855, in which it appears that the rate of mortality, not only in infants and aged persons, but also in those affected with chronic disease, increases during the winter months, and diminishes in summer. The deaths in many instances (in old persons) were due to pneumonia, bronchitis, asthma, and various chronic diseases; so that Dr. Carpenter is led to observe that "cold brings quickly to a fatal termination many maladies which it does not directly induce." Nay, the acute inflammatory attack, under such circumstances, is often enough the first intimation, to the patient, and perhaps to the physician, of the existence of organic change in the affected organ. A most common error, and, as far as I know, a universal one, is to date the real beginning of the disease from the acute inflammation, and ascribe any recognizable lingering symptoms to the acute attack having "lapsed into the chronic form;" when, in fact, the slow, chronic changes of structure were present only in their naturally-designed latent form,[2] long before, and were only made manifest to the patient by the disturbing action of cold.

As we have seen that, in organisms undergoing physiological development, those organs are most liable to be attacked with inflammation after exposure, whose rate of growth happens to be at the time most rapid, so in after-life it is not all the organs in the body that are liable to inflame after exposure, but only those in which pathological evolution is taking place. And this explains why it is, when several persons have been equally exposed, that one suffers from acute pneumonia, another from acute nephritis (kidney-inflammation), another from acute arthritis (joint-inflammation), while some altogether escape

[1] American edition of 1856, p. 864.

[2] That processes of pathological development *can* be latent, like physiological evolution, will be shown hereafter.

any unpleasant effect: these last were organically sound before exposure, and the same after it. In external, *visible* parts, that are the seat of injury or disease, or that have been wounded by the surgeon's knife, and which are undergoing the process of tissue-repair, we *see* redness and congestion follow exposure to cold, and often enough hear the patient not only complain of pain, but date its commencement from known exposure, and express his belief—reached as if by instinct—that "cold had settled on the part."

Again, as young animals instinctively dread cold, and as Nature provides them means for warmth, so in individuals undergoing evolution of a pathological kind, we observe a like instinctive dread of exposure, and a liability to be easily "chilled," while means of protection are also instinctively resorted to. The extra quilt at night; the heavy wrapper during the day; the thick woolen under-garments; the flannel "chest-protector;" the late fires in spring, and early ones in autumn, so necessary for the comfort of the invalid—what are they but imitations of the means supplied by Nature for the preservation of warmth in young animals undergoing physiological development?

We have further proof that organs undergoing pathological evolution are liable to be disturbed by cold in the manner referred to, and also that the existence of the evolutionary process is itself one of the conditions without which (in the absence of others) inflammation, after exposure, would not take place, in the fact that attacks of inflammation occur *repeatedly in the same organ.* Thus, to take a familiar illustration, it has been long ago observed that some people are liable to repeated attacks of inflammation of the lungs (pneumonia). Andral records a case of a patient who had fifteen attacks in eleven years; Chomel has seen ten recurrences, J. P. Frank eleven, and Rust has recorded twenty-eight attacks, in the same individual. A patient of Ziemssen's had four attacks in five years. It is also observed that, of the two lungs, the one first affected is most liable to suffer from subsequent attacks. In thirty-five cases of recurrence collected by Grisolle, the return of the disease was noted twenty-five times in the lung first affected. In the other ten, the disease changed sides (*see* Reynolds's "System of Medicine," vol. iii., p. 613).

The limits of the present paper precluding a very prolonged argument, we leave this part of the subject, hoping that what has been said is sufficient to account for the mortality of pathological processes which, we have said, are designedly conservative.

We may now further follow out the analogy between physiological and pathological evolution, by observing that *structures undergoing pathological development* (*conservative organic modification*), *like those that are being developed physiologically*, *manifest an intrinsic tendency*, *when undisturbed in their progress*, *to pursue a fixed*, *typical course to their naturally-designed termination. When permitted to*

*pursue such a typical course, the observed structural changes are exceedingly slow, and are attended with little or no physical suffering.*

Let us speak, first, of physiological evolution. And, to begin, let us ask, "How shall we know when physiological development is following its natural course, and when it is not?" There are two striking characteristics which can always here be taken as guides, viz., *slowness of organic change*, and *latency*. The physiological growth of tissue is always *gradual* in its progress, both as regards change of shape, bulk, and variation in physical properties. These go on with an insidious progression that is, for the most part, quite imperceptible to ordinary methods of observation. *Natura non facet saltem.* Abrupt changes of shape, size, etc., incident to *function*, are, of course, quite common, but these are only temporary, and quite distinct from the more stable organic changes constituting growth. Indeed, it may be taken as an invariable rule that structural changes of any considerable extent, that occur abruptly and remain permanent, are always unnatural, and are to be attributed to the action, direct or indirect, of some disturbing cause.

Secondly, we notice that the natural course of physiological development is characterized by painlessness—unconsciousness on the part of the individual that any tissue-changes at all are taking place. As the height of perfection in function, as in digestion, for example, consists in ignorance or unconsciousness of the existence of the organs performing it, so is it an invariable quality of every perfectly natural organic change that it should take place without the knowledge of the individual—I mean without any knowledge derived from unpleasant sensations. No argument is needed to support this statement; we will only add that, when physiological organic changes *are* accompanied with pain, it is always attributable to some injurious influence having caused the changes that are taking place to deviate from their natural and typical course.

A third characteristic of undisturbed physiological evolution is this: the developed organs, when their evolution is complete, and indeed during their development, present a *typical uniformity of structure*; that is to say, organisms whose development has been perfectly natural, provided they are of the same age, sex, species, etc., are alike; and the several organs of different individuals present a uniform standard of size, shape, and functional power, any slight existing differences being so inappreciable as to evade ordinary methods of observation. This uniformity of type, however, will only be observed in wild animals that have led a strictly natural life, untrammeled by domestication, such as ocean and river fish that have not been removed from their natural waters, wild birds, reptiles, insects, and the untamed mammalian animals. So exactly similar in such instances are the nutritive changes of waste and repair, growth and development, that not only are the size and shape uniformly the same,

but even the color of the exterior presents the same unvarying uniformity of shade. The spots on the leopard and on the butterfly's wing, the speckles and stripes on the reptile, the scales of the fish, the plumage of the bird, and the fur of quadrupeds, are tinted so precisely alike in different individuals of the same species, age, etc., that we find it difficult to detect the slightest variation. Any appreciable deviation from the standard type must always be attributed to the action of some unusual cause disturbing the normal course of evolution, unnumbered instances of which appear among domesticated animals, where, in fact, uniformity is the exception and variety quite common.

Now, to go back to *pathological* evolution, we find the three qualities of *graduality*, *latency*, and *uniformity of type*, to belong also to it, i. e., when it has followed its undisturbed typical course. We observe, however, that graduality—slowness of organic change—is common only to so-called *chronic* pathological changes; in *acute* organic diseases (those that we have seen destroy life) the change of tissue is rapid; hence an organ undergoing pathological modification that becomes the seat of an acute process (of an acute inflammation) can no longer be said to have followed its designed typical course, and we can no longer anticipate the same attaining of the pathological evolution to its designed conservative, typical completion. The acute disease is accompanied with fever, hence with rapid wasting and reduced assimilation of food; it leaves the whole organism reduced in vital power, and there remain behind inflammatory products which require to be removed; the normal progress of the gradual pathological development has been arrested; the vitality *of the part* has been weakened; there is set up in it a tendency to degeneration or local death. Indeed, time would fail us to enumerate all the injurious consequences, immediate and remote, general and local, that are liable to follow even a single acute inflammatory attack. No wonder, when such attacks occur more than once, or are repeated over and over again, that the pathologically developing organ fails of reaching its designed conservative termination; it need never surprise us, under such circumstances, that the final result is degeneration and death instead of preservation and repair.

In the several instances (very simple ones) of admitted conservative modifications of structure previously mentioned, we observed that *time* was an important element. The enlargement of anastomosing arteries that took place after the main vessel had been tied, did so by *slow degrees;* so did the hypertrophy of the heart that followed more general arterial obstruction; so did the transformation of mucous membrane into skin when exposed to air; and so do all conservative modifications of structure when they have been allowed to pursue, undisturbed, their designed typical course.

Secondly, when typical pathological evolution follows its designed

course, it is devoid of symptoms, *latent;* the tissue-changes going on do not make known their existence by pain or unpleasant sensations. Did space permit I might quote without limit from medical authorities to prove not only the occurrence, but the quite frequent occurrence, of organic changes of structure in their "latent form." The index of almost any text-book on "Pathology," or "Practice," will direct the reader to ample evidence on this point. I will, however, cite one or two well-known authors. Prof. George B. Wood, of Philadelphia, remarks[1] that "sometimes inflammation" (he *must* refer to sub-acute or chronic inflammation) "runs its accustomed course, so far as relates to its effects upon the textures in which it is seated, with scarcely any of those evidences by which its existence in the interior of the body is usually detected, such as *pain*, *disordered function*, and constitutional disturbance. Under such circumstances it is said to be latent, and often escapes detection."[2]

Prof. Austin Flint ("Practice of Medicine," pp. 307, 308) refers to cases of what he calls "spontaneous" or "idiopathic endocarditis" (organic modification of the lining membrane of the heart) "which present the physical signs and anatomical characters of the disease *without the first symptom having been noticed either by the patient or his physician.*" The terms "latent pleurisy," "latent phthisis," "latent pneumonia," etc., are familiar to every pathologist. With regard to this latter disease I cannot refrain from inserting one other citation from the "Works of Dr. Thomas Addison" (*see* "New Sydenham Society's Publications," article "Pneumonia," p. 11). Dr. Addison remarks that Laennec referred to *pneumonia without symptoms* as of rare but occasional occurrence, and adds: "I am convinced that these reputed deviations and exceptions, regarded as obscure, are of extremely frequent occurrence; and that they are met with at every period of life, and in every variety of constitution; and that they are very far indeed from being limited to old persons, or to what have been called complicated cases. . . . Cases with symptoms are in truth themselves the exceptions in a pathological sense; and, although most frequently met with in practice, are in fact cases of complication." This most apt statement is replete with wisdom, and true to Nature. Truly, the simplest form of the disease, that in which the tissue-changes are gradual (chronic), and without symptoms (latent), is rarely met with *in practice*, because the pathological evolution has followed so closely its designed course undisturbed, that the physician is never

[1] "Practice of Medicine," vol. i., p. 38.

[2] Dr. Wood, in here using the term "inflammation," is still possessed with the old error (long ago set aside by the researches of Dr. Handfield Jones and others), that the growth of fibrous (connective) tissue (the supposed "effect of inflammation upon the textures in which it is seated"), is always due to inflammation. Really this abnormal growth of fibrous tissue is a "new formation," the result of an evolutionary process, and is found after death from inflammation only because it *preceded the inflammatory process*, and was by this latter brought to a fatal termination.

sent for and never needed any more than he would be in a case of undisturbed *physiological* evolution. Both are more or less precarious conditions, liable to disturbance and complication; but, while *un*complicated and *un*disturbed, they are both equally conservative, equally devoid of symptoms, and seldom come under the surveillance of the practitioner. Thus the supposed "insidious stealth" and "fatal subtlety" of organic disease is, in reality, the *normal latency* of typical pathological evolution.

It is almost unnecessary to add that latent changes are of necessity slow; hence the two qualities of *chronicity* and *latency* go hand-in-hand, and both are wanting in supervening acute inflammatory complications.

The third quality which we have said belongs to organs developed (or developing) physiologically is, *conformity of structure to a fixed typical standard.*

It may, perhaps, be less easy to point out instances of conformity to a fixed type of structure in pathological formations, for the reason, among others, that pathological evolutionary processes are more often interrupted and made to deviate from their intended type than those which are strictly physiological. Organisms follow the course of physiological evolution easily and happily; pathological evolution is something superadded, and, while conservative, is still the result of unnatural external surroundings, and is therefore less easy and auspicious. Furthermore, we may be less familiar with the finished standard of structure which a typical pathological growth is aiming to reach, than we are with one that is physiological, because the former are more rare than the latter, and hence less frequently observed and studied; physiology occurs in every organism; pathology only in some. Physiological organisms may be observed in great numbers together; pathological ones are exceptional and isolated. The typical standard of physiological development is known, because its existence has been believed in and consequently searched for; the standard type of pathological new formations is not so exactly known, because its existence has not been so universally acknowledged, and hence not so diligently sought after.

Again, organisms undergoing pathological evolution frequently die from the direct effect or remote results of acute inflammation, and here the designed type of structure is obscured by the inflammatory process, so that what it *would have been* in the absence of inflammation cannot always be made out. True, as we have before seen, organisms undergoing physiological evolution die in the same way, and therefore present the same obscurity. In the latter case, however, we observe that, while the designed type of development is obscured in the inflamed parts, the remainder of the organs have pursued *their* physiological development unimpaired. In pathological evolution this is not the case; that is to say, the organs remaining not in-

flamed do not present unimpaired pathological evolution, but, on the contrary, furnish still additional instances of physiological development. It is chiefly, therefore, in cases of accidental sudden death from violence that the designed type of development (both pathological and physiological) can be studied best at all. But here, again, specimens of pathological evolution would occur less often than those that are physiological: first, because the whole number of pathological cases is less than the physiological ones; and, second, because individuals undergoing pathological development are less exposed to the liability of death by violence; they, like young individuals undergoing physiological evolution, require more rest, warmth, and frequent feeding, and are less strong and vigorous, than others whose physiological development has been completed, and who are, therefore, more disposed to cope with the risks and hardships of out-door life and labor, under which circumstances death from violence more frequently occurs.

At any rate, it is nothing else than an axiomatic proposition that similar organisms, impressed with similar stimuli, under similar circumstances, will lead to the development of similar structures. Now, it is evidently only by the rarest possibility that we could meet, in the civilized human subject, with a succession of instances in which all these conditions had prevailed. In man and domesticated animals, it is even observed that *physiological* growth differs widely, but, within certain limits, in different individuals of the same age, species, etc.: it is only in wild animals and plants that we observe uniformity of type; much less, then, need we expect to find this uniformity in evolutionary processes that are pathological; especially, too, when it is only sought for in man and domestic animals.

Finally, notwithstanding the difficulties I have mentioned, enough subservience to a fixed type on the part of pathological new formations has been observed, especially in cases where the new growth and its cause have been limited and simple, to warrant the assertion that pathological evolution in this respect is analogous with physiological development.

This analogy may be further established by considering various other disturbing conditions (in addition to cold) which act disastrously alike in the two kinds of evolution; but this may be reserved for a subsequent paper, when we may also present a *new method of study*, based upon the views herein laid down, and by the pursuit of which it is possible the nature, cause, and prevention of disease, may be investigated more after the manner of the exact sciences.

# THE MICROSCOPE AND ITS MISINTERPRETATIONS.

By JOHN MICHELS.

THE old adage that "seeing is believing" has long been exploded, and folks nowadays receive with caution the impressions conveyed by their eyesight.

There is still, however, a fixed idea with many people that, when the human sight is aided by powerful and correctly-constructed optical instruments, full reliance can be placed upon such united powers, and that the investigator may record that which he believes he sees, as veritable and established facts.

In contradiction of such belief, I shall place before the reader some curious results, which will show that the utmost caution is required by those using optical instruments for the elucidation of scientific problems or ordinary research.

Quite an interesting paper could be written upon the optical delusions with which astronomers have to contend in the use of the telescope, but I propose to confine my remarks to the difficulties

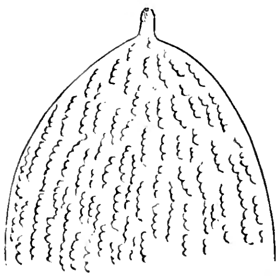

FIG. 1.—DRAWING BY DR. PIGGOTT, SHOWING THE BEADED MARKINGS ON PODURA-SCALE.

which beset the path of the microscopist, in obtaining truthful and accurate results, while using the microscope, leading to the most contradictory statements from men whose powers of observation and skill in the use of the instrument are admitted.

Those who make use of a microscope for the first time are usually fascinated by the wonderful and beautiful appearances presented, and, having illuminated the object under examination with a flood of light, and focused it to their satisfaction, congratulate themselves upon the ease with which they have handled the instrument, and fondly believe they have attained to a knowledge of its use. More extended study, however, and the use of high powers with the more complicated pieces of apparatus, soon convince the student that the instrument requires the most delicate manipulation, and that much practice is necessary before its true powers are developed.

Until full command over a microscope has been acquired, the most contradictory and perplexing results are obtained by those who use high powers in the examination of difficult objects, especially if the subject is very transparent. Things examined yesterday appear quite different to-day, both in form and color; and, even while the eye is still fixed upon the object, a slight change in the position of the mirror will alter its appearance, or present entirely new features.

Again, an object mounted in different mediums, or without any, will present the most varied appearances, and the honest investigator is thus embarrassed to decide which is the true form.

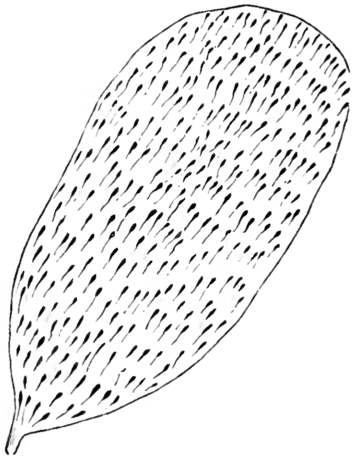

Fig. 2.—Same Scale focused to show Note of Exclamation Marks.

These complications follow the use of the instrument through all its stages; but, when the causes are well understood, the difficulties are reduced to a minimum, and even turned to account in the examination of difficult objects.

Great success in the use of the microscope can only be obtained by the skillful manipulation of the light, and he that is not acquainted with the numerous schemes, devices, and contrivances in its management, might as well be in the dark; no directions here avail, and nothing but diligent and constant practice will render the student efficient in this respect.

I once stood an hour watching a leading London optician struggling to show me the true markings of a diatom with a new object-glass he had recently constructed, with which he had had no previous difficulty. He at last gave up the attempt in despair. Of course, an objective that has once performed a specific test will do so again. In this case, the only thing in fault was the management of the light. This had disgraced the object-glass, and enraged its maker.

In contrast with the above case, I may mention the real pleasure

I experienced in witnessing the skill of a professional microscopist of this country. In his hands, all difficulties appeared to vanish, and he showed me one of the most difficult objects known, with marvelous promptitude.

But, to return to my subject: To enable the student to familiarize himself with the true power of the microscope, and to train his eyes to detect errors of vision, certain well-known test-objects are in general use; which are also convenient to test the quality and power of objectives. A favorite object of this class is the scale of the Podura, a minute insect, which dwells in remote nooks of dark and damp cellars, and similar localities.

This scale is usually mounted dry, and, when viewed under the compound microscope with suitable objectives, presents a surface studded with marks similar to the well-known note of exclamation (!)

This test-object has been for years the delight of microscopists possessing high powers, and a sharp definition of its peculiar markings as above mentioned was accepted as its true appearance and form.

For twenty-five years this scale was under constant examination by every grade of microscopists, from the grandees of the Royal Microscopical Society to the humble tyro, without any new or special feature being noticed, when on November 10, 1869, Dr. G. W. Royston Piggott, F. R. M. S., read a paper "On High-Power Definition" before the Royal Microscopical Society, and surprised the members by stating

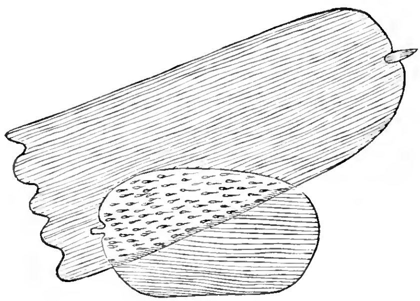

FIG. 3.—SCALE OF AZURE BLUE, PLACED IN POSITION, TO SHOW FALSE MARKINGS SIMILAR TO TEST PODURA-SCALES.—(Piggott.)

that all these years they had been gazing at the podura-scale, but had never yet seen its true markings. Dr. Piggott's paper described very fully what he had discovered as the true markings, and illustrated it with drawings which represented them to be distinctly of a beaded character; in fact, as dissimilar from the old accepted idea of their form as contrast could depict them.

Every microscopist was now hunting poduræ, and cellars damp and dismal were ransacked for the little scale-bearers, doubtless to the astonishment of numerous colonies of spiders, who must have been much provoked by this invasion, and thus commenced a contro-

versy which is not yet concluded. Men equally eminent have taken opposite sides and expressed the most contrary opinions; and I now propose to give a brief *résumé* of what has been said and done in regard to this subject, because the matter is full of instruction to those interested in microscopical research. Not that the markings of the podura are of the slightest importance, or have any scientific significance, but the gravity of the conclusions which are sought hinges upon the fact that, if the views of Dr. Piggott are correct, our most eminent microscopists have been promulgating false and erroneous statements respecting the form of a well-known and common object; and, in whatever light the controversy is viewed, the humiliating confession must be made that they are still unable to determine the correct focus or the proper method of illuminating it.

Dr. Piggott commences by calling resolving the podura-scale "a difficult enterprise," and then describes the beaded appearance in the following manner: "Under a low power, as 80 or 100, the podura-scale is remarkable for its wavy markings, compared to watered silk; raising the power to 200 or 250, and using a side-light, the waviness disappears, and in its place longitudinal *ribbing* appears; with 1,200, they divide themselves into a string of longitudinal beads; but with 2,300 they appear to lie in the same plane and terminate abruptly on the basic membrane; in focusing for the beads attached to the lower side, the beadings appear in the intercostal spaces."

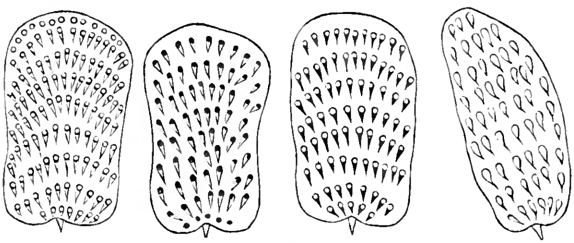

FIG. 4.—THE SAME PODURA-SCALE AS VIEWED UNDER DIFFERENT PHASES OF OBLIQUE LIGHT. —(Westropp.)

Respecting the old received views of the podura-scale, Dr. Piggott says: "With 300 to 500, the celebrated 'spines' appear, according to the size of the scale, as very dark tapering marks (like 'notes of admiration' without the dots ! ! !). To see these clearly with 2,500 has been considered the *ne plus ultra* of microscopical triumphs, and it is consequently with no small diffidence that the writer ventures to traverse the belief of twenty-five years."

Dr. Piggott further states that he reckons these beads to be $\frac{1}{500000}$ to $\frac{1}{1500000}$ of an inch in diameter, and that the "spines," which he calls spurious, really embrace in general three or four beads, while the intervening space abounds with beads seen through the basic membrane, and very difficult of observation without special management;

and concludes with the remark that he expects in a few months the podura beadings, such as he described them, will be fully established.

Thus was the gauntlet thrown down, and the challenge was at once accepted by various members of the Society, who, on the conclusion of the reading of the paper, at once disputed the new doctrine. Mr. J. Beck was the first to express an opinion, and rather increased the confusion of the subject by stating that both the spines and the beads were illusory, and that the true structure of the podura-scale was a series of corrugations on one side, and that the reverse side was slightly undulating or nearly smooth, and that the notes of exclamation were due to refraction of light.

Mr. Hogg, the Hon. Secretary of the Society, thought Dr. Piggott in error; he had never seen such appearances as beads; thought probably Dr. Piggott had seen them by using too deep an eye-piece, bad illumination, and drawing out the tube of the microscope to too great an extent; or, perhaps, to a disturbed vision caused by advanced age and presbyopia.

The President, the Rev. J. B. Read, followed by stating that he agreed with the observations made by Mr. Hogg, and such was his faith in the skill of the opticians of the day, that he could not but feel that what he saw with their instruments really existed.

On the same date and occasion on which Dr. Piggott expounded his views, Mr. S. J. McIntire, a member of the same Society, read a paper "On the Scales of Certain Insects of the Order Thysanura." Now, Mr. McIntire, although a recent member, and young in microscopical research, is always listened to on this subject with respect by the Society,

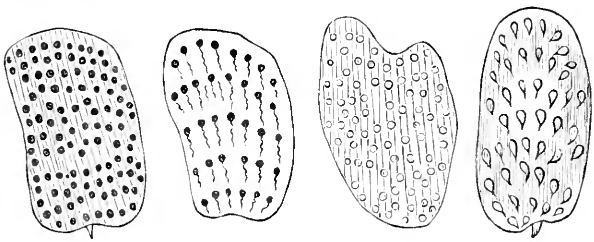

FIG. 5.

having devoted his attention specially to these insects, and shown a patient and intelligent power of observing, not only their structure but their habits; he, in his communication, opposed Dr. Piggott's views, and calls the beads "optical illusions," and concurred with Mr. Beck's statement that the surface of the scale is corrugated, but flatly contradicts him by stating that both sides are alike.

*December* 8, 1869.—The President, the Rev. J. B. Read, stated that he, with Dr. Miller and others, had interviewed Dr. Piggott, and was bound to say he had seen the beaded appearances, and it was clear to

him, *now*, that in the best object-glasses small residuary aberration existed.

This slur upon the best object-glasses brought out Mr. Wenham with a paper in the *Microscopical Journal* of June, 1870, in which he repudiated such error, and described the beaded appearance as an illusion, obtained by a trick of illumination, and by examining the scale with the microscope out of focus.

At the June meeting of the Royal Microscopical Society, a letter was read from Colonel Woodward, of Washington, inclosing photographs of the podura-scale, showing what he considered to be the true appearance. These photographs showed the spines. Colonel Woodward, however, reserved his opinion, and asked for a specimen of the true test podura-scale.

Dr. Maddox, in August, exhibited various photographs of podura-scales, which Mr. Wenham commented on in a paper to the *Microscopical Journal* of September following, which merely reiterated his views that the "*spines*" were the true appearance of podura-scales.

The Rev. J. B. Read, in the *Popular Science Review* of April, 1870, appears to accept Dr. Piggott's views entirely, and writes: "I can now see with my own powers what has been before invisible, viz., the beautiful beaded structure of the whole test-scale, as discovered by Dr. Piggott."

It would be tedious to continue the subject and give even an outline of the papers and discussions that have been provoked by this knotty question: I shall, therefore, conclude by stating that Colonel Woodward has since produced two photographs, showing the two aspects of the question; they are made from authentic scales, and are pronounced very perfect.

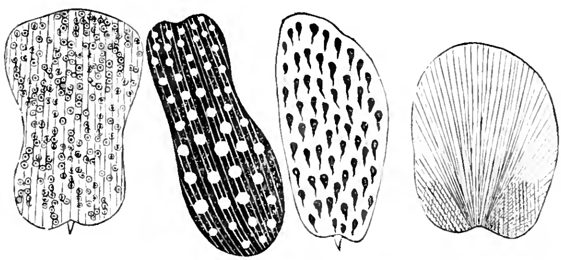

Fig. 6.

In further illustration of the difficulty of obtaining a true and reliable image of an object when viewed under the microscope with high powers, I offer drawings which have been made by Mr. Ralph H. Westropp, B. A., T. C. D., of Allyflin Park, England, and represented at Figs. 4, 5, 6. These figures all represent the same object, a scale of podura viewed under different phases of oblique light; they are interesting as showing the effect produced by the play of light upon a

refractive object. The reader will note that not only the details of the markings are greatly changed, but the very outline of the figures.

The fact that the most skillful microscopists of the age all differ upon the true appearances of a common and not very minute object, and the microscope itself presenting to the vision the most opposite appearances of one and the same object, should act as a caution to those who accept too readily theories based upon microscopical research; and suggests that, in the cause of justice, when life is at stake, single-handed evidence relating to the microscopical examination of apparent blood-stains should be verified at least by a second person before being accepted.

Thus we see that the so-called revelations of the microscope are but hieroglyphics, needing the interpretation of a mind of the highest culture, and that while the microscope is a good servant it is a bad master—mighty in the hands of a Huxley, but as useless to a man without the powers of discrimination as the chisel of Michael Angelo would be in the hands of a Modoc.

# THE MIGRATION OF INLAND BIRDS.

By CHARLES C. ABBOTT, M. D.

AS understood by us, the migration of a bird is simply the desertion of a given locality by that species for a certain, and always the same, portion of each year. As an example, the common house-wren (*Troglodytes ædon*) is migratory, in that it remains in New Jersey[1] only from late in April until late in September, having left its Southern home for six months.

Before endeavoring to determine the causes of this movement on the part of some birds, we must first note the various features characterizing the movement itself; for it may safely be asserted that no two birds migrate alike, although the similarity is marked among the various species of the same family. The most marked feature in migration is the apparent uniformity in the time of its occurrence, i. e., of the dates of the arrivals in spring, and of the departures in autumn. Is this arrival in spring as regular as claimed by some, and supposed by most people? To the casual observer, and, indeed, to many who have for years noted the first appearances of our various birds, the arrival seems to be quite regular; and, curiously enough, we find many such observers insisting that, however late a bird may be any one season, he is never earlier than a given date. Thus we

[1] The observations upon which this essay is based were made by the author during the past sixteen years, while residing at Trenton, New Jersey, and the dates of arrival and departure of the various birds that we give refer solely to them, as seen in that locality.

have been frequently told that a wren is never seen before the 1st of May, and *usually* upon that day they are here in full force. Now, let any one be determined to watch day and night for the first birds of the season; let him wander all day in or about tangled thickets, and sheltered, sunny hill-sides; let him, with sleepless eye, scrutinize every haunt of the birds, and with vigilant ear listen to every faint chirp and far-off twitter, and follow up every undetermined bird-note; let him do this, year after year, from April 1st to 30th, and he will find his note-books teeming with records of "early" birds, that will come and go, all unsuspected by the mid-day observer, who often will insist upon the absence altogether of many a summer songster, that, skulking about, withholds its joyous songs until the woods have welcomed the full company of its kind, that of old have made merry in its shady nooks. The fact is, there is more to be learned about birds, in one hour of the early morning, than in six weeks of mid-day sunshine.

The amount of variation in the dates of arrival of all of our spring birds is really considerable, and in the whole list of migratory inland birds that annually visit New Jersey, either to remain throughout the summer, or are on their way to more northern localities, there is not one that can be considered regular in the time of reaching here, by from twenty to thirty days.

The amount of variation in the dates of arrival, year after year, of the same species, say of the brown thrush, cat-bird, or yellow-breasted chat, is less, however, than that of the time of arrival of allied species; for instance, the various species of thrushes reach us very irregularly. The robin (*Turdus migratorius*) is a resident species; the wood-thrush appears (one or two in a neighborhood) from April 15th to May 10th; the tawny thrush (*Turdus fuscescens*) sometimes later by two weeks, and sometimes absent altogether; the olive-back thrush (*Turdus Swainsoni*) passes by irregularly, as to both time and seasons, and so, too, with the hermit thrush (*Turdus Pallasi*), which, however, occasionally remains throughout the summer. The brown thrush, or "thrasher" (*Harporhynchus rufus*), comes to us by twos and threes as early as April 20th (the first recorded by me this season, 1874, was April 17th), and not until May 3d to the 12th can they be considered as present in full force. The mocking-bird (*Mimus polyglottis*) is irregular, both as to years and dates, and the cat-bird (*Galeoscoptes Carolinensis*), never missing a year, wants the early May foliage developed, that he may skulk therein, yet often in "single blessedness," comes to his last year's haunts, and is wonderfully ingenious in his efforts to conceal himself in the leafless thickets of early April, keeping ever close to the ground, and never venturing upon the slightest attempt at a song.

The many notes we have made with reference to the warblers (*Sylvicolidæ*) also indicate a great degree of irregularity and uncertainty in their migratory movements. This applies to these birds as

a family not only, but to all of the various species separately, of which a score or more pass through the State as a general thing. During certain seasons we have noticed a marked preponderance of some one or two warblers, which for seasons following were much less common than many others. Thus, in 1860, 1864, 1867, and 1872, the common redstarts (*Setophaga ruticilla*) were very abundant, not only about their natural haunts, but within the city limits, and scores of them could be seen climbing over and flitting through the branches of the shade-trees of the less-frequented streets. Since 1872 these birds have not been so numerous as usual, and far less so than many other warblers, such as the yellow-rumped (*Dendroica coronata*), the black-throated blue (*D. cærulescens*), or even the chestnut-sided (*D. Pennsylvanica*).

Unlike the thrushes, the warblers seem to be wholly controlled by meteorological influences and sudden changes of the weather, which, unlike some birds, they seem unable to foretell, greatly influence their movements, and certainly delay their northward progress; and yet, while we have frequently known them to be caught in a "north-easter," they are not otherwise affected by it, so far as we could determine, other than by the delay, before mentioned. Even a sudden change from warm, summer-like weather to decided cold did not destroy any of them, apparently, or check their lively movements among the trees.

Let us glance at the well-known and noticed swallows. For five months of every year we have with us, in greater or less abundance, six species of swallows and one "swift," the common chimney-swallow. Of these, one, the rough-winged (*Stelgidopteryx serripennis*) is comparatively rare, and known only to ornithologists; the white-bellied (*Hirundo bicolor*) are not particularly abundant, except during certain seasons; the cliff-swallow (*Petrochelidon lunifrons*) is erratic, now here, about the barns and stables of a circumscribed neighborhood, for several years, and then wholly failing to appear in their former haunts, when spring comes slowly up this way, to greet May's sleeping blossoms. Not so, however, with the barn-swallow (*Hirundo horreorum*); with a variation in date of arrival of about ten days, we have come to us, in May, our full complement of these beautiful birds. They have decreased in numbers during the past thirty years, so observant old farmers have told us, but probably not so much as they think. It is more probably the increase in the numbers of other species that makes the numbers of the barn-swallow seem fewer. The bank-swallow (*Cotyle riparia*), earliest of all, is here literally by millions, and the purple martin (*Progne subis*), in moderate numbers, seldom fails to occupy the boxes placed for its accommodation; while, lastly, the chimney-swallow (*Chætura pelagica*), which really belongs to another family, nearer the humming-birds and goat-suckers, we believe, has never failed to appear in about the same numbers, year after

year. We have fewer instances recorded of single swallows, seen at unusually early dates, than of birds of any other family. Some, indeed, arrive much earlier than do others, as, for instance, the bank-swallow; but the variation in date of arrival, throughout any ten years, is certainly much less than with other birds, and with some of them it is surprisingly regular, but not absolutely so, as so often asserted.

Let us now glance at the peculiarities of this family of birds, and compare them with the thrushes and warblers. One marked difference at once is seen; that is, that the swallows have a wonderful flight-power, and the thrushes and warblers are weak in their powers of flight, positively as well as comparatively: and our observations bear us out in asserting, as a law of migration, that its regularity is in proportion to and solely dependent on the flight-powers of the species. With the entire list of inland birds of New Jersey, we believe this to hold good.

We have already expressed our belief that many birds have the ability to foretell a coming storm. As this is not directly connected with the subject of our essay, as we are now considering it, we will pass to another feature of this prophetic power, as it apparently is, in birds, and that is, their ability to judge of the general character of the coming season, by a visit of a few days' duration early in spring. We have so frequently noticed that certain birds, common to a locality during the summer, occasionally fail to visit it, except one or two individuals, that in April come for a few days, that it has appeared to us that these "pioneer" birds saw satisfactory reasons for believing that there would be a scarcity of food, and so return to meet their fellows, and informing them, they all depart to "fresh fields and pastures new," just as a single crow, discovering danger, will turn a whole colony from their course as they are going to their roosting-place. This, be it understood, is our supposition, and may be wholly untrue; but how are we to interpret the meaning of any habit or particular movement of a bird, except by the human standard? An act on the part of a bird is intelligible to us only as we would interpret a corresponding act in man; and these acts in birds and men, producing allied results, indicate that close connection between all animal life which is so readily comprehended from an evolution stand-point. Now, as an instance of this "foretelling" power in birds, we noted, during the past spring, the arrival of the first chewink (*Pipilo erythrophthalmus*) on April 27th. Busily among the dried leaves and tangled briers it hopped, enlivening the thicket with its constant song just as a dozen of its kind had done throughout the preceding summer. In a few days it had disappeared, and not a chewink has been seen or heard for nearly six months. Now a few are noticed on their way south from the country north of us. This locality is one where these birds usually congregate, and we have often found a dozen nests in the limits of the spot. But a few miles away, these birds were as abundant as usual. In

two ways we can explain the absence of these birds: either those that were accustomed to occupy it went to a new locality, and the single bird that had preceded them, finding his companions did not come, left, rather than remain alone; or he left to announce that food would be scarce, for it must be remembered, as Darwin has remarked, "most animals and plants keep to their proper homes, and do not needlessly wander about; we see this, even with migratory birds, which almost always return to the same spot." At any rate, the summer of 1874, in this neighborhood, was the driest in the past forty years, and it seemed as if the chewink knew what was coming. So, at least, we believe. During this season we noted the entire absence, during the summer, of several migratory birds, common, as a rule, and a very marked decrease in the numbers of those that did appear; but, at the same time, our note-books mention the arrival of one or more individuals of every one of our migratory birds. Many, like the chewink, foresaw what was coming and acted accordingly. It would be most interesting to determine if insect-life was less abundant than usual during the past summer, but concerning this we have only to note, as suggestive that it was so, a marked freedom of the fruit-trees and fruit itself from the attacks of their insect enemies.

Another feature of the migration of our inland birds must here be briefly referred to; and that is, the failure of late years of certain species to come, as a rule, as far north as New Jersey; and also the habit, now fully acquired by others, of remaining throughout the year, when, but a comparatively short time ago, these same birds were truly migratory.

As an instance: the summer red-bird (*Pyranga æstiva*), twenty years ago, was a regular visitor to Central New Jersey, arriving about May 1st and remaining until October. It nested on trees, frequently in apple-orchards, laying pretty purple-blotched, green eggs. It preferred wooded hill-sides with a growth of underbrush, and having a southern exposure. In such situations they were numerous, and to one such locality, in particular, we can well remember the charm they added to the scene by the bright gleam of their plumage as they passed from tree to tree, uttering their peculiar but not melodious notes. For the past fifteen years we have seen not half a dozen individuals, and recorded no nests since 1857. In far scantier numbers the scarlet tanager (*Pyranga rubra*) has taken their place, although this bird is not rare by any means, nor was it so when the preceding species was abundant.

It is much the same with the mocking-bird (*Mimus polyglottis*). Formerly, as regular in its appearance, if not as abundant, as the cat-bird, it is now among our rarest summer visitors. An occasional pair, selecting some well-tangled thicket, will come late or early, and build their nest, and then half a dozen years may elapse before we see them again. Yet, thirty years ago these birds were common.

As instances of "spring arrivals," as we will class them, that have become resident species, we will first mention the well-known bluebird (*Sialia sialis*), which, whatever may be the state of the weather, is as lively and full of song from November 1st to April as from April to November; yet it is still considered as a migratory species, and formerly, we doubt not, was so, even in New Jersey. More interest-are the two instances yet to mention, being those of the common yellow-rumped warbler (*Dendroica coronata*), which, in scanty numbers, braves our winters and from the tops of the loftier pines chirps merrily while the snow-flakes fill the air, and later in the winter seeks shelter in protected nooks where the noonday sun has melted the snow and gives us a breath of spring-like air. In several such spots, since February, 1863, when we shot the first "winter" specimen, we have not failed to find several individuals of this species, during each of the winter months, and of their number that thus remain with us there seems to be a steady increase. The same remarks will apply, in part, to that beautiful but not well-known songster, Bewick's wren (*Thryothorus Bewickii*). They too, in scanty numbers, congregate in sheltered places having a southern outlook, and now, while we are writing (October 29th) we can hear the clear notes of this lively bird as it sits, braving a chilly westerly wind, perched on a leafless branch of a sycamore.

We have noted now the more prominent features in the migratory habits of our inland birds as they come to us in May from the South, save the one fact, the bearing of which upon the subject we cannot determine, that a large proportion of the birds perform the journey by night, the others wholly by day. At least this is the common impression, but it is difficult to demonstrate it. How little, really, we know of the precise *modus operandi* of migration! All through April and May, if astir at the earliest dawn, when the resident birds are just starting their morning songs, we will occasionally hear the welcome notes of some summer bird for the first time. Has it been winging its way northward through the thick, black hours of night, guided by some unknown sense, and no sooner above its old-time haunts than it checks its onward course, and from a familiar tree sings with grateful heart a loud thanksgiving glee?

If we wander about those quiet nooks and by-ways, where the first thrushes and warblers are likely to be seen these same months, we will find all the day long, and evening too, these birds "conspicuous for their absence." Not a chirp or twitter, save of the sparrows and tits of all the year, and the lingering snow-birds that seem to regret leaving our pleasant places. Far into the night we may remain, and only the startled chirp of some disturbed or dreaming bird, or the fret and scolding of little owls, greet our ears. The silence of midnight may pass unbroken, and then, as the first gray streaks of light in the hazy east herald the oncoming day, suddenly a cheerful warble

from some tall cedar or tangled brier-patch breaks the dead silence, and we mark the arrival of the first spring songster of its kind. Did it reach us at sunset, and, resting a few hours, then announce its presence with its cheery song?

Both by day and by night, it may be, they come, but why at all by night, if so, must ever be a great mystery in the strange habit of migration.

Let us next study our birds during the autumn.

A careful examination of the many notes, jotted down at irregular intervals, during the months of September, October, and November, with respect to the departure south of such of our birds as are summer residents, and of some that, having passed the summer in regions far to the north, are now, likewise, seeking their accustomed winter-quarters, indicates a similar apparent regularity in the southward movements of our birds as in spring, and at the same time an actual degree of variation in the dates of departure exceeding the irregularity of the dates of arrival.

If we consider the several circumstances that would necessarily influence their migratory movements, this actual irregularity, in autumn, is just what should be expected; but in the spring, as every bird returns to its own home and former nest, if possible, they will not linger on the way, as they know too well the length of the journey, and the coming duties of incubation speed them on, and we wonder why they are not more regular in their movements. In autumn, all this is changed. Now nothing need hurry them, and, so long as they find an abundance of food, they leisurely move along, just keeping ahead, as it seems, of the chilling frosts of the coming winter, which they can easily endure, but which robs them of the food they must have. This is especially true of insect-eating birds. Considered in this light, we are not surprised to find, then, as a rule, that the warblers, swallows, and such other birds as depend wholly upon insects for their sustenance, leave more promptly and in larger numbers, at one time, than do granivorous birds, and those that *can* subsist on seeds, while they consume insects so long as they can find them.

The weather, both during September and October, is exceedingly variable, and this fact causes the southward movements of the migratory, insect-eating birds equally so, inasmuch as these birds are not larvæ-hunting species, but depend upon insects that can be caught upon the wing, or are to be found resting upon the leaves and twigs of the trees; therefore, just so long as the heavy white frosts are delayed, these insectivorous birds will linger with us. Up to a certain date, about October 1st on the average, these birds largely increase in numbers, consequent upon the daily accession of those from the north, and after the maximum is reached (October 1st or earlier, in accordance with the weather), their number steadily decreases, until but a few stragglers remain.

We feel quite confident that in exceptionally mild winters many more migratory birds winter in Southern New Jersey than ornithologists suspect; and we can see, in the lingering remnant of the great flight of warblers that annually pass through the State, that gradual adaptation to surrounding conditions, on the part of birds, that as centuries roll by, evolve, by that mystery of mysteries, the "survival of the fittest," new species from the old.

Again, long after the true insect-eaters, such as the fly-catchers (*Tyrannidæ*), the vireos (*Vireonidæ*), and the swallows (*Hirundinidæ*), with the chimney-swallow, humming-bird (*Trochilus colubris*), whippoorwill (*Antrostomus vociferus*), night-hawk (*Chordeiles popetue*), and the two cuckoos (*Coccygus Americanus* and *erythrophthalmus*), have passed southward, beyond the limits of the State, and scarcely a leaf is left upon the forest-trees, when not one straggling fly-catcher, in a day's walk, can be found hovering about the many spots so lately tenanted by myriads of their kind, we have yet the pleasure of seeing, in our rambles, many a blithe sparrow, either in the fields or about leafless hedges, or haunting the still green but nearly deserted swampy meadows, and even, late as it is, an occasional grosbeak, as it half conceals its gorgeous ruby and black plumage in some dark cedar, while it utters in broken cadences a fragment of its glorious song.

Of our many sparrows, of which several are resident species, we have noted down for several years, when the severity of the winter was yet to come, even as late as December 14th, the presence of the pretty bay-winged bunting (*Poocætes gramineus*), and in less scanty numbers the quiet little field-sparrow (*Spizella pusilla*). In the wet, reedy meadows, it is not until winter has encased in ice the tangled grasses, that the swamp-sparrow quits its home. For two years past, we have noticed that in the dry upland fields, all through November's hazy Indian summer, the sprightly black-throated bunting (*Euspiza Americana*) still remains, in little companies; and in the quiet woodlands, ever and anon, a retiring grosbeak (*Hedymeles melanocephalus*) lingers, until biting north winds drive him from his summer haunts. Last year, the indigo-bird (*Cyanospiza cyanea*) until the 20th of November remained with us, singing as merrily from the bare branches of the maples as when, during the summer, they cheered their brooding mates with almost ceaseless song. The bobolink, in spite of the persecution they suffer from sportsmen, hold to their reedy haunts, in scattering pairs, often until the first fall of snow, and this same bird—"reed-bird" in autumn (*Dolichonyx oryzivorus*)—being seen so early in the spring, occasionally, may possibly remain, but if so, very rarely. A few red-winged blackbirds (*Agelaius phœniceus*), we know, withstand our winters, and seem to find food somewhere and how, even when the thermometer is at zero.

This difference between the insect-eating and the granivorous

birds, the more prolonged autumn stay of the latter, we think, explains itself. In the spring, there is an object ever in view, while on their journey north—in autumn, their sole care is to be home in time; not so much to escape the coming cold, as to avoid being pinched by hunger.

We have seen that the first frost that but little affects vegetation does materially decrease insect-life; the swallows even anticipate this first frost, and, gathering in immense flocks, wing their way southward long before it comes. We can clearly see that the weather greatly influences, indeed governs, the migratory movements, in autumn, of the insect-eaters. It bids them depart, and, in general, they heed the bidding; but long after this, while there are yet berries, seeds, and fruits, to be obtained, the migratory vegetarians linger, in varying numbers, by the way.

Let us now glance at the abundant and well-known purple grakle or crow-blackbird (*Quiscalus purpureus*). The numbers of this (with us) partially migratory species that remain throughout the winter, as compared with those which are here during the spring and summer months, are about as three to one hundred, as near as we can judge; and, in proportion as the winter is mild, the percentage of those that remain is increased. In Massachusetts, this bird is strictly migratory; the great bulk of those that depart from the north, and from New Jersey, wintering in the Carolinas and Georgia. In this species, therefore, we have an example of a migratory bird that is gradually becoming more and more accustomed, not to the rigors of winter which birds are better able to withstand than they are supposed to be, but to the methods of our winter residents, such as woodpeckers, jays, and titmice, in procuring such food as can then be procured. Food, as a matter of course, and an abundance of it, must necessarily be obtained, and, on examination of the stomachs of grakles killed in January, we have found them filled with a half-digested mass of what appeared to be both animal and vegetable matter. If the grakles that remain during the winter are of a hardier constitution than those that migrate, then, as they mate very early in the year, and before the great bulk of the southern sojourners reach us, their offspring will naturally inherit equally vigorous constitutions, and, like their parents, will be more disposed to remain; at least a large proportion of them will be, and in this way, wholly through natural selection, a *race* of grakles, otherwise undistinguishable from the whole number of this *species*, will be evolved, that in time will wholly replace (?) the now migratory and semi-migratory individuals. If we have now correctly explained a change now in progress, in the habits of this and other species, then can we not, from it, gain a clew to one, at least, of the original causes of the habit of migrating?

But this we will discuss in the concluding part of our essay.

The act of migrating being the passage from one distant point to

another, it is evident that the cause or causes of this movement is one or more that operates at either terminus of the journey. A warbler that winters in Florida, and breeds near the arctic circle, is operated upon by a cause that exists at each terminus, or by two differing causes, each peculiar to its own location, and it is wholly incredible that it is the same cause that induces both the visit to northern regions and the return to a southern clime; therefore there must be at least two causes for the habit—one inducing it in the spring, another compelling the migrating bird to return. If it be possible now to demonstrate what these causes are, and how the same cause can influence all migratory birds, considering that their habits are otherwise so totally different, it will not then necessarily follow that it was the originating cause of the habit. When, indeed, did this migration commence? How far back into the world's geological history must we go, to trace the first bird that was forced to seek another and far-distant land, wherein to rear its young and find for its offspring and itself sufficient food? What conditions of heat and cold, land and water, summer and winter, then obtained, that birds must need fly from coming rigors of scorching sun, or ice and floods, or perish where they were? Was it from living in such a world that migration originated, and became, strangely enough, characteristic of only a fraction of the whole number? How, too, could birds have learned the oncoming of disastrous times, and know just where to seek a safe harbor and secure rest? Clearly it could have been only by a very gradual accumulation of experiences extending over many generations, before the few progenitors of our many birds gained the happy knowledge, that here in the North we have months of sunny summer weather and a wealth of pleasant places. We will not go back, then, of the Glacial period, but rest content with it as having been the starting-point in time of birds' migratory movements. The progenitor of our score of warblers, the one tyrant fly-catcher, from which all our species have sprung, the vireos, the goat-suckers, and cuckoos, then very few in species, if indeed there were more than one of each, must have been influenced by the presence of the icy barriers that shut them off for the time being from a vast portion of the northern world, and at the close or closing of that wonderful period it may be that migration commenced, yet why and how, we can but guess. Knowing that it commenced then or recommenced, if previously a feature of bird-life, we have now to inquire what are its apparent causes at present; but, before inquiring into these, may we not, after all, ask if migration be not an inherited habit, the originating causes of which are not now in operation? The conditions not obtaining that necessitate migration, does it not become a case of survival of habit, just as in man many customs now exist, the origin and proper meaning of which are wholly lost? That this is true of the migration of all birds we do not believe, but that it partially holds good with some species we are fully convinced. As an inherited

habit, but one now not absolutely necessary to the bird's welfare, we can see why it should be, as it frequently is, so greatly influenced by surrounding circumstances and conditions.

Taking the movement from its proper starting-point, which we assume to be the movement from south to north, in the three spring months, we must now look for sufficient causes to induce the undertaking of such long journeys. These causes are suggested by the two principal objects effected, on their arrival at their northern destination, viz., rearing of their young, and procuring suitable and sufficient food for both themselves and offspring. If migration is for these two purposes only, then it should prove to be the case that food was not sufficiently abundant in the south for both its resident and migratory birds. This certainly could not have been the case, and we believe, therefore, that migratory movements, at the outset, were to a very limited extent only; a few birds at a time seeking to avoid their enemies, and have undisturbed possession of a locality, by pushing out from their accustomed haunts, for, comparatively speaking, a few miles. The young of such pioneer birds would naturally leave the neighborhood of their nest, and return to their parents' usual haunt with them; but, on the return of another breeding-season, they would themselves seek a resting-place near where they themselves were reared, and the older birds would go to the same nest or nesting-place that a year ago they occupied. This is precisely what occurs now, year after year. Now, as birds increased, century after century, the limits of this northward movement would be extended, until it became in time the journey of thousands of miles that it now is.

Assuming, then, that migration arose for the dual purpose of safe nidification and a certainty of sufficient food, we are met by the ugly question, "Why do not all the southern birds come north?" If, when the whole avi-fauna was concentrated at the south, there was any struggle whatever for favorable feeding or breeding grounds, then, naturally, the weaker would go to the wall, or, in other words, would be driven beyond the limits of their accustomed habitat. These weaker birds, taken together, having once formed the habit of visiting certain localities at stated times for given purposes, or periodically were forced to do so, would vary in their methods of reaching these localities, in their choice of regions wherein to remain, and the length of their annual visit, just in proportion as their habits generally varied from those of both other species of the same family and from species of other families. For instance, to avoid a common enemy, a number of species might have gradually learned to migrate at night; while others, although forced to migrate, had not this same enemy to contend with. In this way, the habit of nocturnal migration would long ago have been formed, and it would, by inheritance, be continued by their descendants, even after the enemy had been long extinct.

Having reached the northern summer homes, and, free from molesta-

tion, reared their broods, clearly, if all things needed for their comfort were to be obtained, it cannot be supposed that these same birds would unnecessarily retrace their long flight to the distant South. This suggests that if we are correct in assuming that birds first appeared in a tropical climate, and from such climate migration started, it is probable that by gradually prolonging their northern visits and accustoming themselves to northern insect and vegetable life, these regions became populated by their resident species. It is evident that the present migratory species are simply compelled to return, and three compelling causes are demonstrable. Primarily, the sudden increase of cold at the close of the brief northern summer, which starts southward those farthest at the north. This accession of intense cold necessarily decreases the amount of food, and the birds are now forced to find it elsewhere. Farther and farther south they come, just in advance of the cold, and slower and slower they proceed, as they enter our more temperate latitude, and here, resting as it were, they linger until a keen frost kills their insect-food, and, scattering the leaves, robs them of their main shelter from their enemies, happily fewer now than formerly; and now still southward they proceed, until they reach a home in lands blessed with perpetual summer.

We have now traced these migratory species from south to north, and back to their southern habitat, and endeavored to point out the several operating causes of the movement as we did so. We have already suggested the possibility of migration being an inherited habit not now necessary. Now, be this true or not, it is evident that the habit is not so fixed a one that ordinary changes in surrounding conditions do not greatly influence it. This, we think, is shown by the irregularity of the movement that really occurs, and the tendency on the part of many species to modify the habit by occasionally halting much to the south of their usual breeding-grounds, and by remaining later and later in autumn; and, again, by the fact that many birds are now only partially migratory, and others by occasionally migrating simply in search of food, thus exhibiting, as it were, traces of a habit they have long lost, as to its full meaning and accomplishment.

In the migration of a bird, then, we see simply a temporary sojourn in a distant locality for the purpose of rearing its offspring in safety; the cause being implied by the term "safety," i. e., freedom from enemies, and an abundance of food.

# SAVAGISM AND CIVILIZATION.[1]

By HUBERT H. BANCROFT.

THE terms savage and civilized, as applied to races of men, are relative and not absolute terms. At best these words mark only broad shifting stages in human progress; the one near the point of departure, the other farther on toward the unattainable end. This progress is one and universal, though of varying rapidity and extent; there are degrees in savagism, and there are degrees in civilization; indeed, though placed in opposition, the one is but a degree of the other. The Haidah, whom we call savage, is as much superior to the Shoshone, the lowest of Americans, as the Aztec is superior to the Haidah, or the European to the Aztec. Looking back some thousands of ages, we of to-day are civilized; looking forward through the same duration of time, we are savages.

Nor is it, in the absence of fixed conditions, and amid the many shades of difference presented by the nations along our Western seaboard, an easy matter to tell where even comparative savagism ends and civilization begins. In the common acceptation of these terms, we may safely call the Central Californians savage, and the Quichés of Guatemala civilized; but between these two extremes are hundreds of peoples, each of which presents some claim for both distinctions. Thus, if the domestication of ruminants, or some knowledge of arts and metals, constitutes civilization, then are the ingenious but half-torpid hyperboreans civilized, for the Esquimaux tame reindeer, and the Thlinkeets are skillful carvers and make use of copper; if the cultivation of the soil, the building of substantial houses of adobe, wood, and stone, with the manufacture of cloth and pottery, denote an exodus from savagism, then are the Pueblos of New Mexico no longer savages; yet in both these instances enough may be seen, either of stupidity or brutishness, to forbid our ranking them with the more advanced Aztecs, Mayas, and Quichés.

We know what savages are; how, like wild animals, they depend for food and raiment upon the spontaneous products of Nature, migrating with the beasts and birds and fishes, burrowing beneath the ground, hiding in caves, or throwing over themselves a shelter of bark, or skins, or branches, or boards, eating or starving as food is abundant or scarce; nevertheless, all of them have made some advancement from their original naked, helpless condition, and have acquired some aids in the procurement of their poor necessities. Primeval man, the only real point of departure, and hence the only true savage, nowhere exists on the globe to-day. Be the animal man ever so low—lower in skill and wisdom than the brute, less active in obtaining food, less ingenious in building his den—the first step out of his houseless, com-

[1] From vol. ii. of "Native Races of the Pacific States."

fortless condition, the first fashioning of a tool, the first attempt to cover nakedness and wall out the wind, if this endeavor springs from intellect and not from instinct, is the first step to civilization. Hence the modern savage is not the prehistoric or primitive man; nor is it among the barbarous nations of to-day that we must look for the rudest barbarism; if proof be wanting, there are the unground edges of the stone implements of Denmark, which denote an order of art lower than that indicated by any relic of the Stone age in America.

Often is the question asked, What is civilization? and the answer comes, The act of civilizing; the state of being civilized. What is the act of civilizing? To reclaim from a savage or barbarous state; to educate; to refine. What is a savage or barbarous state? A wild, uncultivated state; a state of Nature. Thus far the dictionaries. The term civilization, then, popularly implies both the transition from a natural to an artificial state, and the artificial condition attained. The derivation of the word civilization, from *civis*, citizen, *civitas*, city, and originally from *coetus*, union, seems to indicate that culture which in feudal times distinguished the occupants of cities from the ill-mannered boors of the country. The word savage, on the other hand, from *silva*, a wood, points to man primeval, *silvestres homines*, men of the forest, not necessarily ferocious or brutal, but children of Nature. From these simple beginnings both words have gradually acquired a broader significance, until by one is understood a state of comfort, intelligence, and refinement, and by the other humanity wild and beastly.

Guizot defines civilization as "an improved condition of man resulting from the establishment of social order in place of the individual independence and lawlessness of the savage or barbarous life;" Buckle as "the triumph of mind over external agents;" Virey as "the development more or less absolute of the moral and intellectual faculties of man united in society;" Burke as the exponent of two principles, "the spirit of a gentleman and the spirit of religion." "Whatever be the characteristics of a gentleman and the spirit of religion." "Whatever be the characteristics of what we call savage life," says John Stuart Mill, "the contrary of these, or the qualities which society puts on as it throws off these, constitute civilization;" and, remarks Emerson, "a nation that has no clothing, no iron, no alphabet, no marriage, no arts of peace, no abstract thought, we call barbarous."

Men talk of civilization, and call it liberty, religion, government, morality. Now, liberty is no more a sign of civilization than tyranny; for the lowest savages are the least governed of all people. Civilized liberty, it is true, marks a more advanced stage than savage liberty, but between these two extremes of liberty there is a necessary age of tyranny, no less significant of an advance on primitive liberty than is constitutional liberty an advance on tyranny. Nor is religion civilization, except in so far as the form and machinery of

sacerdotal rites and the abandonment of fetichism for monotheism become significant of intenser thought and expansion of intellect. No nation ever practised grosser immorality, or what we of the present day hold to be immorality, than Greece during the height of her intellectual refinement. Peace is no more civilization than war, virtue than vice, good than evil. All these are the incidents, not the essence, of civilization.

That which we commonly call civilization is not an adjunct or an acquirement of man; it is neither a creed nor a polity, neither science, nor philosophy, nor industry; it is rather the measure of progressional force implanted in man, the general fund of the nation's wealth, learning, and refinement, the storehouse of accumulated results, the essence of all best worth preserving from the distillations of good and the distillations of evil. It is a something between men, no less than a something within them; for neither an isolated man nor an association of brutes can by any possibility become civilized.

Further than this, civilization is not only the measure of aggregated human experiences, but it is a living working principle. It is a social transition; a moving forward rather than an end attained; a developing vitality rather than a fixed entity; it is the effort or aim at refinement rather than refinement itself; it is labor with a view to improvement, and not improvement consummated, although it may be and is the metre of such improvement. And this accords with latter-day teachings. Although in its infancy, and, moreover, unable to explain things unexplainable, the science of evolution thus far has proved that the normal condition of the human race, as well as that of physical Nature, is progressional; that the plant in a congenial soil is not more sure to grow than is humanity with favorable surroundings certain to advance. Nay, more, we speak of the progress of civilization as of something that moves on of its own accord; we may, if we will, recognize in this onward movement the same principle of life manifest in Nature and in the individual man.

To things we do not understand we give names, with which, by frequent use, we become familiar, when we fancy that we know all about the things themselves. At the first glance, civilization appears to be a simple matter: to be well clad, well housed, and well fed; to be intelligent and cultured, are better than nakedness and ignorance; therefore it is a good thing, a thing that men do well to strive for—and that is all. But once attempt to go below this placid surface, and investigate the nature of progressional phenomena, and we find ourselves launched upon an eternity of ocean, and in pursuit of the same occult Cause, which has been sought alike by philosophic and barbaric of every age and nation; we find ourselves face to face with a great mystery, to which we stand in the same relation as to other great mysteries, such as the origin of things, the principle of life, the soul-nature. When such questions are answered as, What is attrac-

tion, heat, electricity; what instinct, intellect, soul? Why are plants forced to grow and molecules to conglomerate and go whirling in huge masses through space?—then we may know why society moves ever onward like a river in channels predetermined. At present, these phenomena we may understand in their action partially, in their essence not at all; we may mark effects, we may recognize the same principle under widely-different conditions, though we may not be able to discover what that principle is. Science tells us that these things are so; that certain combinations of certain elements are inevitably followed by certain results, but Science does not attempt to explain why they are so.

In every living thing there is an element of continuous growth; in every aggregation of living things there is an element of continuous improvement. In the first instance, a vital actuality appears; whence, no one can tell. As the organism matures, a new germ is formed, which, as the parent stock decays, takes its place, and becomes in like manner the parent of a successor. Thus, even death is but the door to new forms of life. In the second instance, a body corporate appears no less a vital actuality than the first; a social organism in which, notwithstanding ceaseless births and deaths, there is a living principle. For, while individuals are born and die, families live; while families are born and die, species live; while species are born and die, organic being assumes new forms and features. Herein the all-pervading principle of life, while flitting, is nevertheless permanent, while transient is yet eternal. But, above and independent of perpetual birth and death is this element of continuous growth, which, like a spirit, walks abroad and mingles in the affairs of men. "All our progress," says Emerson, "is an unfolding, like the vegetable bud. You have first an instinct; then an opinion, then a knowledge, as the plant has root, bud, and fruit."

Under favorable conditions, and up to a certain point, stocks improve; by a law of natural selection the strongest and fittest survive, while the ill-favored and deformed perish; under conditions unfavorable to development, stocks remain stationary or deteriorate. Paradoxically, so far as we know, organs and organisms are no more perfect now than in the beginning; animal instincts are no keener, nor are their habitudes essentially changed. No one denies that stocks improve, for such improvement is perceptible and permanent; many deny that organisms improve, for, if there be improvement it is imperceptible, and has thus far escaped proof. But, however this may be, it is palpable that the mind, and not the body, is the instrument and object of the progressional impulse.

Man, in the duality of his nature, is brought under two distinct dominions: materially he is subject to the laws that govern matter, mentally to the laws that govern mind; physiologically, he is perfectly made and non-progressive; psychologically, he is embryonic

and progressive. Between these internal and external forces, between moral and material activities there may be, in some instances, an apparent antagonism. The mind may be developed in excess and to the detriment of the body, and the body may be developed in excess and to the detriment of the mind.

The animal man is a bundle of organs, with instincts implanted that set them in motion; man, intellectually, is a bundle of sentiments, with an implanted soul that keeps them effervescent; mankind in the mass, society—we see the fermentations, we mark the transitions; is there, then, a soul in aggregated humanity as there is in individual humanity?

The instincts of man's animality teach the organs to perform their functions as perfectly at the first as at the last; the instincts of man's intellectuality urge him on in an eternal race for something better, in which perfection is never attained nor attainable; in society, we see the constant growth, the higher and yet higher development; now, in this ever-onward movement are there instincts which originate and govern action in the body social as in the body individual? Is not society a bundle of organs, with an implanted soul of progress, which moves mankind along in a resistless predetermined march?

The strangest part of all is, that though wrought out by man as the instrument, and while acting in the capacity of a free agent, this spirit of progress is wholly independent of the will of man. Though in our individual actions we imagine ourselves directed only by our free-will, yet in the end it is most difficult to determine what is the result of free-will, and what of inexorable environment. While we think we are regulating our affairs, our affairs are regulating us. We plan out improvements, predetermine the best course, and follow it, sometimes; yet, for all that, the principle of social progress is not the man, is not in the man, forms no constituent of his physical or psychical individual being; it is the social atmosphere into which the man is born, into which he brings nothing, and from which he takes nothing. While a member of society he adds his quota to the general fund, and there leaves it; while acting as a free agent, he performs his part in working out this problem of social development, performs it unconsciously, willing or unwilling, he performs it, his baser passions being as powerful instruments of progress as his nobler; for avarice drives on intellect as effectually as benevolence, hate as love, and selfishness does infinitely more for the progress of mankind than philanthropy. Thus is humanity played upon by this principle of progress, and the music sometimes is wonderful: green fields, as if by magic, take the place of wild forests; magnificent cities rise out of the ground, the forces of Nature are brought under the dominion of man's intelligence, and senseless substance is endowed with speech and action.

As to the causes which originate progressional phenomena there are differences of opinion. One sees in the intellect the germ of an

eternal unfolding; another recognizes in the soul-element the vital principle of progress, and attributes to religion all the benefits of enlightenment; one builds a theory on the groundwork of a fundamental and innate morality; another discovers in the forces of Nature the controlling influence upon man's destiny; while yet others, as we have seen, believe accumulative and inherent nervous force to be the media through which culture is transmitted. Some believe that moral causes create the physical; others, that physical causes create the moral.

Thus Mr. Buckle attempts to prove that man's development is wholly dependent upon his physical surroundings. Huxley points to a system of reflex actions—mind acting on matter, and matter on mind—as the possible culture-basis. Darwin advances the doctrine of an evolution from vivified matter as the principle of progressive development. In the transmutation of nerve-element from parents to children, Bagehot sees "the continuous force which binds age to age, which enables each to begin with some improvement on the last, if the last did itself improve; which makes each civilization not a set of detached dots, but a line of color, surely enhancing shade by shade." Some see in human progress the ever-ruling hand of a Divine Providence, others the results of man's skill; with some it is free-will, with others necessity; some believe that intellectual development springs from better systems of government, others that wealth lies at the foundation of all culture; every philosopher recognizes some cause, invents some system, or brings human actions under the dominion of some species of law.

As in animals of the same genus or species, inhabiting widely-different localities, we see the results of common instincts, so in the evolutions of the human race, divided by time or space, we see the same general principles at work. So, too, it would seem, whether species are one or many, whether man is a perfectly created being or an evolution from a lower form, that all the human races of the globe are formed on one model and governed by the same laws. In the customs, languages, and myths, of ages and nations far removed from each other in all social, moral, and mental characteristics, innumerable and striking analogies exist. Not only have all nations weapons, but many who are separated from each other by a hemisphere use the same weapon; not only is belief universal, but many relate the same myth; and to suppose the bow and arrow to have had a common origin, or that all flood-myths, and myths of a future life, are but offshoots from Noachic and Biblical narratives, is scarcely reasonable.

It is easier to tell what civilization is not, and what it does not spring from, than what it is and what its origin. To attribute its rise to any of the principles, ethical, political, or material, that come under the cognizance of man, is fallacy, for it is as much an entity as any other primeval principle; nor may we, with Archbishop Whately,

entertain the doctrine that civilization never could have arisen had not the Creator appeared upon earth as the first instructor; for, unfortunately for this hypothesis, the aboriginals supposedly so taught, were scarcely civilized at all, and compare unfavorably with the other all-perfect works of creation; so that this sort of reasoning like innumerable other attempts of man to limit the powers of Omnipotence, and narrow them down to our weak understandings, is little else than puerility.

Nor, as we have seen, is this act of civilizing the effect of volition; nor, as will hereafter more clearly appear, does it arise from an inherent principle of good any more than from an inherent principle of evil. The ultimate result, though difficult of proof, we take for granted to be good, but the agencies employed for its consummation number among them more of those we call evil than of those we call good. The isolated individual never, by any possibility, can become civilized like the social man; he cannot even speak, and without a flow of words there can be no complete flow of thought. Send him forth away from his fellow-man to roam the forest with the wild beasts, and he would be almost as wild and beastlike as his companions; it is doubtful if he would ever fashion a tool, but would not rather with his claws alone procure his food, and forever remain as he now is, the most impotent of animals. The intellect, by which means alone man rises above other animals, never could work, because the intellect is quickened only as it comes in contact with intellect. The germ of development therein implanted cannot unfold singly any more than the organism can bear fruit singly. It is a well-established fact that the mind without language cannot fully develop; it is likewise established that language is not inherent, that it springs up between men, not in them. Language, like civilization, belongs to society, and is in no wise a part or the property of the individual.

We may hold, then, *a priori*, that this progressional principle exists; that it exists not more in the man than around him; that it requires an atmosphere in which to live, as life in the body requires an atmosphere which is its vital breath, and that this atmosphere is generated only by the contact of man with man. Under analysis this social atmosphere appears to be composed of two opposing principles —good and evil—which, like attraction and repulsion, or positive and negative electricity, underlie all activities. One is as essential to progress as the other; either, in excess or disproportionately administered, like an excess of oxygen or of hydrogen in the air, becomes pernicious, engenders social disruptions and decay, which continue until the equilibrium is restored; yet all the while with the progress of humanity the good increases, while the evil diminishes. Every impulse incident to humanity is born of the union of these two opposing principles. For example, as I have said, and will attempt more fully to show further on, association is the first requisite of progress.

But what is to bring about association? Naked nomads will not voluntarily yield up their freedom, quit their wanderings, hold conventions and pass resolutions concerning the greatest good to the greatest number; patriotism, love, benevolence, brotherly kindness, will not bring savage men together; extrinsic force must be employed, an iron hand must be laid upon them which will compel them to unite, else there can be no civilization; and to accomplish this first great good to man—to compel mankind to take the initial step toward the amelioration of their condition—it is ordained that an evil, or what to us of these latter times is surely an evil, come forward—and that evil is war.

Primeval man, in his social organization, is patriarchal, spreading out over vast domains in little bands or families, just large enough to be able successfully to cope with wild beasts. And in that state humanity would forever remain did not some terrible cause force these bands to confederate. War is an evil, originating in hateful passions and ending in dire misery; yet without war, without this evil, man would forever remain primitive. But something more is necessary. War brings men together for a purpose, but it is insufficient to hold them together; for, when the cause which compacted them no longer exists, they speedily scatter, each going his own way. Then comes in superstition to the aid of progress. A successful leader is first feared as a man, then reverenced as a supernatural being, and finally himself, or his descendant, in the flesh or in tradition, is worshiped as a god. Then an unearthly fear comes upon mankind, and the ruler, perceiving his power, begins to tyrannize over his fellows. Both superstition and tyranny are evils; yet, without war, superstition, and tyranny, dire evils, civilization, which many deem the highest good, never by any possibility, as human nature is, could be. But more of the conditions of progress hereafter; what I wish to establish here is, that evil is no less a stimulant of development than good, and that in this principle of progress are manifest the same antagonism of forces apparent throughout physical Nature; the same oppugnant energies, attractive and repulsive, positive and negative, everywhere existing. It is impossible for two or more individuals to be brought into contact with each other, whether through causes or for purposes good or evil, without ultimate improvement to both. I say whether through causes or for purposes good or evil, for, to the all-pervading principle of evil, civilization is as much indebted as to the all-pervading principle of good. Indeed, the beneficial influences of this unwelcome element have never been generally recognized. Whatever be this principle of evil, whatever man would be without it, the fact is clearly evident that to it civilization, whatever that may be, owes its existence. "The whole tendency of political economy and philosophical history," says Lecky, "which reveal the physiology of society, is to show that the happiness and welfare of mankind are

evolved much more from our selfish than what are termed our virtuous acts." No wonder that devil-worship obtains, in certain parts, when to his demon the savage finds himself indebted for skill not only to overthrow subordinate deities, but to cure diseases, to will an enemy to death, to minister to the welfare of departed friends, as well as to add materially to his earthly store of comforts. The world, such as it is, man finds himself destined for a time to inhabit. Within him and around him the involuntary occupant perceives two agencies at work; agencies apparently oppugnant, yet both tending to one end—improvement; and Night or Day, Love or Crime, leads all souls to the Good, as Emerson sings. The principle of evil acts as a perpetual stimulant, the principle of good as a reward of merit. United in their operation, there is a constant tendency toward a better condition, a higher state; apart, the result would be inaction. For, civilization being a progression and not a fixed condition, without incentives, that is without something to escape from and something to escape to, there could be no transition, and hence no civilization.

Had man been placed in the world perfected and sinless, obviously there would be no such thing as progress. The absence of evil implies perfect good, and perfect good perfect happiness. Were man sinless and yet capable of increasing in knowledge, the incentive would be wanting, for, if perfectly happy, why should he struggle to become happier? The advent of civilization is in the appearance of a want, and the first act of civilization springs from the attempt to supply the want. The man or nation that wants nothing remains inactive, and hence does not advance; so that it is not in what we have but in what we have not that civilization consists. These wants are forced upon us, implanted within us, inseparable from our being; they increase with an increasing supply, grow hungry from what they feed on; in quick succession, aspirations, emulations, and ambitions, spring up and chase each other, keeping the fire of discontent ever glowing, and the whole human race effervescent.

The tendency of civilizing force, like the tendency of mechanical force, is toward an equilibrium, toward a never-attainable rest. Obviously there can be no perfect equilibrium, no perfect rest, until all evil disappears, but in that event the end of progress would be attained, and humanity would be perfect and sinless.

Man at the outset is not what he may be, he is capable of improvement, or rather, of growth; but childlike, the savage does not care to improve, and consequently must be scourged into it. Advancement is the ultimate natural or normal state of man; humanity on this earth is destined some day to be relatively, if not absolutely, good and happy.

The healthy body has appetites, in the gratification of which lies its chiefest enjoyment; the healthy mind asserts more and more its independence. Increasing skill yields ever-increased delights, which

encourage and reward our labor. This, up to a certain point; but with wealth and luxury comes relaxed energy. Without necessity there is no labor; without labor no advancement. Corporeal necessity first forces corporeal activity; then the intellect goes to work to contrive means whereby labor may be lessened and made more productive.

The discontent which arises from discomfort lies at the root of every movement; but, then, comfort is a relative term, and complete satisfaction is never attained. Indeed, as a rule, the more squalid and miserable the race, the more are they disposed to settle down and content themselves in their state of discomfort. What is discomfort to one is luxury to another; "the mark of rank in Nature is capacity for pain;" in following the intellectual life, the higher the culture the greater the discontent; the greater the acquisition, the more eagerly do men press forward toward some higher and greater imaginary good. We all know that blessings in excess become the direst curses; but few are conscious where the benefit of a blessing terminates and the curse begins, and fewer still of those who are able thus to discriminate have the moral strength to act upon that knowledge. As a good in excess is an evil, so evil as it enlarges outdoes itself and tends toward self-annihilation. If we but look about us, we must see that to burn up the world in order to rid it of gross evil—a dogma held by some—is unnecessary, for accumulative evils ever tend toward reaction. Excessive evils are soonest remedied; the equilibrium of the evil must be maintained, or the annihilation of the evil ensues.

Institutions and principles essentially good at one time are essentially evils at another time. The very aids and agencies of civilization become afterward the greatest drags upon progress. At one time it would seem that blind faith was essential to improvement, at another time skepticism—at one time order and morality, at another time lawlessness and rapine; for so it has ever been, and whether peace and smiling plenty, or fierce upheavals and dismemberments predominate, from every social spasm as well as fecund leisure, civilization shoots forward in its endless course. The very evils which are regarded as infamous by a higher culture were the necessary stepping-stones to that higher life. As we have seen, no nation ever did or can emerge from barbarism without first placing its neck under the yokes of despotism and superstition; therefore, despotism and superstition, now dire evils, were once essential benefits. No religion ever attained its full development except under persecution. Our present evils are constantly working out for humanity unforeseen good. All systems of wrongs and fanaticisms are but preparing us for and urging us on to a higher state.

If, then, civilization is a predestined, ineluctable, and eternal march away from things evil toward that which is good, it must be that throughout the world the principle of good is ever increasing and that

of evil decreasing. And this is true. Not only does evil decrease, but the tendency is ever toward its disappearance. Gradually the confines of civilization broaden; the central principle of human progress attains greater intensity, and the mind assumes more and more its lordly power over matter.

The moment we attempt to search out the cause of any onward movement we at once encounter this principle of evil. The old-time aphorism that life is a perpetual struggle; the first maxim of social ethics, "The greatest happiness to the greatest number;" indeed, every thought and action of our lives points in the same direction. From what is it mankind is so eager to escape? With what do we wrestle? For what do we strive? We fly from that which gives pain to that which gives pleasure; we wrestle with agencies which bar our escape from a state of infelicity; we long for happiness.

There is another thought in this connection well worthy our attention. In orthodox and popular parlance, labor is a curse entailed on man by vindictive justice; yet, viewed as a civilizing agent, labor is man's greatest blessing. Throughout all Nature there is no such thing found as absolute inertness; and, as in matter, so with regard to our faculties, no sooner do they begin to rest than they begin to rot, and even in the rotting they can obtain no rest. One of the chief objects of labor is to get gain, and Dr. Johnson holds that "men are seldom more innocently employed than when they are making money."

Human experience teaches, that in the effort is greater pleasure than in the end attained; that labor is the normal condition of man; that in acquisition, that is progress, is the highest happiness; that passive enjoyment is inferior to the exhilaration of active attempt. Now imagine the absence from the world of this spirit of evil, and what would be the result? Total inaction. But, before inaction can become more pleasurable than action, man's nature must be changed. Not to say that evil is a good thing, clearly there is a goodness in things evil; and in as far as the state of escaping from evil is more pleasurable than the state of evil escaped from, in so far is evil conducive to happiness.

Another more plausible and partially correct assertion is, that by the development of the subjective part of our nature, objective humanity becomes degenerated. The intellectual cannot be wrought up to the highest state of cultivation except at the expense of the physical, nor the physical fully developed without limiting the mental. The efforts of the mind draw from the energies of the body; the highest and healthiest vigor of the body can only be attained when the mind is at rest, or in a state of careless activity. In answer to which I should say that, beyond a certain point, it is true; one would hardly train successfully for a prize-fight and the tripos at the same time; but that the non-intellectual savage, as a race, is physically superior, capable of enduring greater fatigue, or more skillful in muscular exer-

cise, than the civilized man, is inconsistent with facts. Civilization has its vices as well as its virtues, savagism has its advantages as well as its demerits.

The evils of savagism are not so great as we imagine; its pleasures more than we are apt to think. As we become more and more removed from evils, their magnitude enlarges; the fear of suffering increases as suffering is less experienced and witnessed. If savagism holds human life in light esteem, civilization makes death more hideous than it really is; if savagism is more cruel, it is less sensitive. Combatants accustomed to frequent encounter think lightly of wounds, and those whose life is oftenest imperilled think least of losing it. Indifference to pain is not necessarily the result of cruelty; it may arise as well from the most exalted sentiment as from the basest.

Civilization not only engenders new vices, but proves the destroyer of many virtues. Among the wealthier classes energy gives way to enjoyment, luxury saps the foundation of labor, progress becomes paralyzed, and, with now and then a noble exception, but few earnest workers in the paths of literature, science, or any of the departments which tend to the improvement of mankind, are to be found among the powerful and the affluent, while the middle classes are absorbed in money-getting, unconsciously thereby, it is true, working toward the ends of civilization.

That civilization is expedient, that it is a good, that it is better than savagism, we who profess to be civilized entertain no doubt. Those who believe otherwise must be ready to deny that health is better than disease, truth than superstition, intellectual power than stupid ignorance; but whether the miseries and vices of savagism, or those of civilization, are the greater, is another question. The tendency of civilization is, on the whole, to purify the morals, to give equal rights to man, to distribute more equally among men the benefits of this world, to meliorate wholesale misery and degradation, offer a higher aim and the means of accomplishing a nobler destiny, to increase the power of the mind and give it dominion over the forces of Nature, to place the material in subservience to the mental, to elevate the individual and regulate society. True, it may be urged that this heaping up of intellectual fruits tends toward monopoly, toward making the rich richer and the poor poorer, but I still hold that the benefits of civilization are for the most part evenly distributed; that wealth beyond one's necessity is generally a curse to the possessor greater than the extreme of poverty, and that the true blessings of culture and refinement, like air and sunshine, are free to all.

Civilization, it is said, multiplies wants, but then they are ennobling wants, better called aspirations, and many of these civilization satisfies.

If civilization breeds new vices, old ones are extinguished by it. Decency and decorum hide the hideousness of vice, drive it into dark corners, and thereby raise the tone of morals and weaken vice. Thus

civilization promotes chastity, elevates woman, breaks down the barriers of hate and superstition between ancient nations and religions; individual energy, the influence of one over the many, becomes less and less felt, and the power of the people becomes stronger.

Civilization in itself cannot but be beneficial to man; that which makes society more refined, more intellectual, less bestial, more courteous; that which cures physical and mental diseases, increases the comforts and luxury of life, purifies religions, makes juster governments, must surely be beneficial; it is the universal principle of evil which impregnates all human affairs, alloying even current coin, which raises the question. That there are evils attending civilization as all other benefits, none can deny, but civilization itself is no evil.

## FORESTS AND RAINFALL.[1]

THE question of the influence of forests on the hydrology of a region is one that has been warmly discussed. Some men of science, Becquerel for example, hold that forests increase the amount of water received by the soil; while others, Marshal Vaillant among them, assert that forests diminish the quantity. Some *savans*, such as M. Mathieu, sub-director of the Nancy School of Forestry, have endeavored, by way experiment, to get together such facts as might, if they did not set the question at rest, at least clear up some points and supply a portion of the experimental data needed for a full explanation at some future time. M. Mathieu undertook to "determine the amount of rain-water received by the soils of two neighboring districts, one of them covered with timber and the other arable land; and to find out whether, in consequence of the covering of trees which intercepts the rain-water, the soil of the woodland is as abundantly watered as that of the open." His conclusion is, that timbered soils receive as much, and more, rain-water than the open country.

These experiments are of great importance; the results obtained are noteworthy, and, taken in connection with Becquerel's observations, seem to be decisive of the question. Still, in order to meet an objection that might be raised against this mode of experimenting, viz., the difficulty of finding two districts near to one another and fairly comparable, we have made experiments from another point of view, which confirm those made by M. Mathieu.

No matter how you select two neighboring districts, it is not easy to prove that they are absolutely comparable to one another. The amount of rainfall may be seriously affected by the altitude, and particularly the relative altitude; by the situation of the district; by the relief and configuration of the land in the surrounding country; and

[1] Translation of a communication to the French Academy of Sciences, by L. Fautiat and A. Sartiaux.

by other unknown conditions which may in a greater or less degree change the direction or the velocity of the rain-current, or the point and degree of condensation of the watery vapor contained in it.

M. Dausse, in a memoir which appeared in the "Annales des Ponts et Chaussées," uses the following argument: "Rain is formed when a warm and humid wind comes in contact with strata of cold air; and since the air of forests is colder and more humid than that of the open, rain must fall there in greater abundance."

To gauge experimentally the influence of forests on the rainfall of a district, or, in other words, to ascertain the condensing power of forests, we have compared the results obtained in observations made: 1. Above the forest; and 2. At the same altitude, and at so small a distance from the forest, that any observable difference could be attributed only to the influence of the latter.

We now made the following observations in the heart of the forest of Halatte, which embraces 5,000 hectares of land. At the height of about six metres (say 20 feet) above a group of oaks and hornbeams eight or nine metres high, we placed a pluviometer, a psychrometer, maximum and minimum thermometers, and an evaporometer, so as to ascertain at that point the amount of rainfall, the degree of saturation of the air, and the rate of temperature and of evaporation.

In the open air, at the distance of only 300 metres from the forest, and at the same height above the ground as in the former case, we placed similar instruments under the same conditions. With regard to the rainfall and the degree of saturation, we give a summary of the first six months' observations, as follows:

| MONTHS. | Amount of Rainfall. | |
|---|---|---|
| | In the Forest. | In the Open. |
| February, 1874 | 18.75 mm. | 18.00 mm. |
| March, " | 15.00 " | 11.75 " |
| April, " | 27.50 " | 25.75 " |
| May, " | 39.25 " | 35.50 " |
| June, " | 51.25 " | 48.25 " |
| July, " | 40.75 " | 37.75 " |
| Total | 192.50 mm. | 177.00 mm. |
| Difference in favor of the forest, 15.50. | | |

| MONTHS. | Degree of Saturation of the Air, in 100ths. | |
|---|---|---|
| | In the Forest. | In the Open. |
| March, 1874 | 71.1 | 70.0 |
| April, " | 64.3 | 64.2 |
| May, " | 64.1 | 60.4 |
| June, " | 60.9 | 60.1 |
| July, " | 54.6 | 53.8 |
| Total | 315.0 | 308.5 |
| Mean | 63.0 | 61.7 |
| Difference in favor of the forest, 1.3. | | |

If these observations, which are still made daily, continue to give the same results, it may then be affirmed that forests constitute vast condensing apparatus, and the conclusion will be inevitable that more rain falls in wooded land than on bare and cultivated soil.—*Comptes Rendus.*

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# THE CYCLONE IN THE UNIVERSE.

By JAMES MACKINTOSH, M. A.

THE science of meteorology is but of yesterday, and yet it has already developed results which throw light upon the genesis of the universe. It has revealed to us the true nature of atmospheric disturbances throughout time and space. The winds no longer blow where they list, and we hear the sound of them and can tell whence they come and whither they go. We know their producing causes, and can foretell, with a considerable degree of accuracy, their force, duration, and direction. Accordingly, the great majority of civilized countries, including China, the oldest of them, have already established weather bureaus, whose business it is to forewarn the mariner of coming tempests, and to give us all a timely notice when we shall require an umbrella or a great-coat.

While these practical results are exceedingly worthy of attention, and inspire us with the hope that the time shall come when perfected instruments, improved methods, and increased knowledge, shall enable the meteorologist to predict with the utmost certainty every atmospheric disturbance, they yet fall into the shade when compared with the magnificent and luminous conceptions which meteorology has added to cosmological science. It has opened to us visions of beauty and order reaching through infinity and eternity. It has given us a clearer glimpse into the workshop of the Almighty.

The principal scientific result of meteorology is the theory of the cyclone. This is its central idea, the point of reference from which every thing is explained. So long as meteorologists tried to explain storms by encountering currents of wind, as did Dové and his school, so long did the science remain merely a laborious, interminable, and apparently useless collection of tabulated facts. It was then in its empirico-historical stage, and could, at the best, only produce such bare generalizations as isobaric and isothermal lines. Averages and darkness ruled throughout. But, when once the light-giving idea of the cyclone was fully grasped, a heavenly radiance dispelled the uncertain gloom, and the science was at once taken out of the range of the merely empirical, and established securely upon a deductive basis.

What, then, is this light-bringing conception of the cyclone? Briefly, as follows: A cyclone consists essentially of a rapidly-ascend-

ing current of air. This involves two other functions: 1. A rushing in of the air at the under part of the ascending current; 2. An outrushing at the upper. Upon the former of these functions, combined with modifying circumstances, depend the peculiar character and career of the under-currents and of the clouds they bear; upon the latter, combined with the same circumstances, the proportions and direction of motion of the upper currents and of the heavy masses of clouds they bear. There appears to be nothing in the nature of the cyclone itself which can determine the motion of either the upper or under current more toward any one point of the compass than toward the others. This direction of motion relative to the ascending column depends upon the direction and velocity of motion of the latter, and of the atmospheric strata in which the influx and efflux take place, modified to some extent by the differing velocities of revolution of the surface of the earth at different parallels of latitude, by the form of the earth's surface, and by the variation in the constitution of the atmosphere. If the cyclone column and the atmospheric strata which it penetrates move in the same direction, and with the same velocity, the influx and efflux will take place in nearly equal quantity, on all sides of the column. If they move with different velocities, the directions of exaggeration and diminution of the influx and efflux can be calculated in the same way as the direction of a vane on a ship's mast, given the directions and velocities of the motion of the wind and of the ship.

This gives the general idea of the cyclone for all space and time, but not the sources of its power. These are to be found in the less specific gravity, potential or actual, of the lower atmospheric strata as compared with that of the higher. Air, and gases generally, expand when heated, and become specifically lighter. It thus tends to rise above the superincumbent colder air. (We see this illustrated in our chimneys every day.) If the air over the surface of a plain becomes heated by contact with it, its specific levity is increased, and it tends to rise. But the density, and therefore weight of air, the temperature and humidity being the same, is inversely as the pressure upon it. Consequently, so long as the diminution of specific gravity caused by increased temperature is balanced in the strata above by the diminution of pressure due to elevation, the heated air cannot ascend very fast. If it had a chimney to rush up, the case would be different; but, not having one, it can only rise slowly by intermingling itself with the superincumbent air. As soon, however, as the diminution of specific gravity due to higher temperature is greater than that due to diminished pressure, the lower stratum will break itself a way through the air above it, and rush up through the opening. This result may be attained, and is generally reached, by favoring circumstances, long before equilibrium is totally destroyed. When once the heated air has thus at a particular point formed itself a channel of escape, the

warm stratum along the surface of the earth rushes toward the opening, and there ascends, while the colder air above descends to take its place. If the ascending column of heated air remained stationary, it is evident that its supply of warm air would soon be exhausted, and the process therefore speedily come to an end. But this is not so. It moves forward to where there is more heated air, just as one might fancy a chimney to travel after a moving fire. The operation can thus go on for a considerable time.

The ascension of air with a higher *sensible* temperature would not alone suffice to supply the tremendous power of the cyclone. The difference of temperature, even in extreme cases between lower and higher strata, is wholly insufficient to account for the enormous energy developed by our cyclones of hundreds of miles in diameter. We therefore require another source of power. Nor have we far to seek it. The sun's rays falling upon dry earth heat it, and thus raise the temperature of the air in contact with it. But if they fall upon our oceans, lakes, and rivers, or upon moist earth, there is another result, of a somewhat different though equally familiar kind. It is this, that some of the water is converted into steam or vapor. Now, every one knows that no amount of heat can raise the temperature of boiling water if it is unconfined. Where, then, does the heat go to? Plainly it is carried off by the vapor in an insensible or latent condition. It is a demonstrated fact that it requires as much heat to convert a quantity of water into steam as it takes to raise the same quantity 1,000° of temperature. The same amount is required to evaporate water without boiling it. Consequently, when the sun's rays evaporate water, a vast amount of heat becomes insensible to our thermometers. It is not annihilated, however, and all that is required in order to make it manifest is simply to condense the vapor into water again.

When the heated air, as already described, rushes up in a column, it becomes subjected to less and less pressure, because there is less and less air above it. Since air in expanding under pressure produces work, and since heat is an equivalent of work, it expends heat in so doing, and is thus lowered in temperature. Consequently, the ascending air rapidly cools as it rises. Now, this air is carrying large quantities of vapor of water with it, which likewise is cooled by expansion. But you cannot cool vapor at any tension below a certain temperature without condensing it; and so, indeed, it happens. The steam carried up by the cyclone is condensed into rain, snow, or hail, and falls to the earth. In condensing it gives forth the enormous quantity of insensible heat which it received from the sun. This heat is imparted to the ascending current, and thus keeps it warmer and therefore specifically lighter than the strata through which it is rising. The heat of the sun, which had been potential in the vapor, is converted into the energy developed by the cyclone.

We thus see that the cyclone is really a kind of vast steam-engine.

On our earth its furnace is the sun, and its boiler the moist lands, the rivers, lakes, and oceans. But it is evident that its mode of operation would not be substantially affected if the heat were supplied not as in our case from an outside source, but from the original internal heat of the sun or planet itself. So, also, the essential nature of the cyclone would not be altered whatever be the kind of vapor condensed, whether it be of water, of iron, of copper, of gold, or of granite. The above derivation of the power of the cyclone is therefore applicable throughout time and space.

For the condensation of any vapor whatever would present very much the same phenomena as those with which we are familiar. Let us suppose the earth of such a temperature as to keep iron in nearly the same condition relatively as water is now; that is, partly vapor floating in the atmosphere, partly fluid gathered in oceans, lakes, and rivers, and partly like solid snow and ice as in the colder seasons and latitudes. Evaporation would go on at the surface of the fluid iron until the atmosphere became nearly saturated. As soon as condensation began an ascending current would be formed. Toward the bottom of this current the winds would rush in spirals just as they do now. As the vapor of iron rose and came to the strata of less and less pressure and temperature, it would expand, cool, and condense, and descend in molten showers of liquid metal. Or, if the temperature were low enough, or the summit of the storm high enough, a shower of iron hail, or snow, would be the result.

Nor need we stay our imagination here. The time was, when our globe had no solid or liquid nucleus, but was wholly gaseous. It was literally an *atmosphere*, and nothing else. All the matter of the earth then floated, a vast globular ocean of vapor. The power which kept its particles apart was heat. Before these particles could come together and the solid foundations of the world be laid, it was necessary that the heat should be got rid of. The means by which this purpose was accomplished was mainly the cyclone. Around the limits of the vaporous world radiation into empty space could go on rapidly. Not so in the interior. Conduction of heat even along a bar of iron is a very slow process. It is million-fold slower through gas. Hence, the quickest way of carrying the heat from the interior to the summit of the atmosphere, where it might escape, was, to carry up the matter itself which contained a large amount of heat, either actual or potential. This work was accomplished by the cyclone.

Let us endeavor to form some conception of the cyclone of primeval times. Let us fancy ourselves in the solar system ere yet it became separated into insulated worlds, and just as condensation is going on. Gases of different specific gravities tend to intermingle even though at first arranged in separate layers above one another. Many of the gases would also be of nearly the same specific gravity. Hence, although in general the denser gases would tend together toward the

centre, and the lighter toward the summit, there would necessarily be a vast amount of confused intermingling. Hence a cyclone of those times could not be attended by the fall of only one kind of rain, as of molten iron, but by that of many different kinds. Doubtless while some substances, such as granite, fell as snow or hail, others, such as iron, would fall as rain.

Moreover, since the strata would be, in the main, according to their specific gravity, and since some of the gases would evaporate and condense at different temperatures from others, showers of different kinds of metals and stones would tend to form at different altitudes. This would be counteracted, at least in part, by the tendency of the cyclone to reach clear up from the lowest depths to the circumference. That the disturbances in our own atmosphere extend to an immensely greater height than is generally supposed, and probably almost to the extreme limit of the atmosphere, is now certain. In my report on the tornado of May 22, 1873 (Chief Signal-Officer's "Annual Report, 1873"), I showed that in all likelihood it reached, at least, to an altitude of sixteen miles. The cyclones in the sun also appear to extend almost to the summit of his atmosphere, otherwise we could not see them so clearly as we do. Judging also from the nature of the case, we should conclude that the cyclone, amid such a vast assemblage of vapors, arranged in layers, would be likely to extend its dimensions almost from the centre to the circumference; for a disturbance and precipitation in one layer would tend to produce a disturbance and precipitation in the stratum above it, as well as in that beneath it. We have thus presented to our imaginations a vast cyclonic column thousands of millions of miles in height, up which vapors of great variety, and collected at very various altitudes, are rushing with terrific force, and condensing as they go. Those, like granite, that solidify at a high temperature, would freeze in huge blocks which, generating sufficient centrifugal force by the whirling motion, would fly out from the ascending current and rush downward. Substances congealing at different temperatures would thus be likely to be thrown out at different elevations. Much the larger mass of substances, however, would probably be carried up to where the cyclone spread itself out laterally in a huge nimbus-cloud. From that cloud would rush down a fierce deluge of half the substances of the solar system in solid or liquid form. The violence and confusion of the descending hail and rain would be of surpassing grandeur—far more terrible and sublime than that scene described by Milton, where the Satanic host was hurled from the battlements of heaven "with hideous ruin and combustion down to bottomless perdition." All kinds of igneous rocks, mingled with molten metal, chased each other millions of miles down through the fiery gloom. The temperature increased as they descended. Each substance melted and evaporated as it reached the proper temperature, while the substances

more difficult to evaporate continued their downward course. Finally, all would again be reduced to a state of vapor.

What, then, had been accomplished by all this turmoil and activity? Merely this: a large quantity of heat had been conveyed from the interior of the system to the exterior; for this it is which all cyclones accomplish. This it is which lends them their power. On our earth it is the sun's heat mainly which the cyclone carries away to the limits of the atmosphere. In the sun itself it is a portion of the primeval stock of heat which is removed.

The cyclone may therefore be defined as the universal cooler of creation. There is not a sun which lights the midnight sky, or which the telescope has brought within mortal ken, which is not vastly indebted to the cyclone. Though so simple as easily to be understood by a child, it is a powerful means by which the Almighty works. It is a key to very many of the secrets of the universe. When we watch the snow-storm and the rain, we are really watching the method by which God has proceeded in forming his worlds since ever the cooling process began. Thus have the storms raged and the winds howled throughout the universe for countless ages; and by that rain, and snow, and hail, has all the solid and liquid substance of the worlds been formed. Every particle of it has been rained and snowed again and again. Nor is the process yet completed. The cyclone has by no means done its work yet. Its task will be finished only when the last particle of gas is converted into a liquid or solid. It is going on all around us. If there appears to be a balance at present upon the earth, if the solidifying power of the cyclone appears to be at a standstill, it is only because its efforts are counteracted by the extraneous heat we receive from the sun.

The cyclone may also have assisted at the birth of the planets. Those stupendous meteors of thousands of millions of miles of elevation must necessarily have caused immense gaseous masses to bulge out from the general level of the surface of the incipient solar system. This might be sufficient under exceptional conditions, and when the balance between the centrifugal and the centripetal forces was nearly equal, to turn it in favor of the former, and thus generate a planet.

## A CURIOUS QUESTION OF HORSES' RIBS.

By MAX MÜLLER.

SYLVIUS said that man had formerly an intermaxillary bone. If he has it no longer, he ought to have it. In this he was right. The same Sylvius, in his answer to Vesalius, said that Galen was not wrong when he described man as having seven bones in his sternum,

"for," said he, "in ancient times the robust chests of heroes might very well have had more bones than our degenerate day can boast." In this he was wrong.

I take these statements from Mr. Lewes's "Life of Goethe" (p. 343), and I have to confess that I have not verified them. They interested me, however, as bearing on a controversy that has been carried on for some time between scholars and anatomists, viz., whether another animal, the horse, instead of losing, has developed in course of time some bones which it did not originally possess. Horses have now thirty-six ribs; sometimes, it is said, thirty-eight. But there is a passage in the "Rig-Veda," which speaks apparently of only thirty-four ribs in horses. It was M. Piétrement, who, in his work "Les Origines du Cheval domestique d'après la Paléontologie, la Zoologie, l'Histoire et la Philologie" (Paris, 1870), first called attention to this curious statement, and drew from it the conclusion, supported by some very ingenious arguments, that at the time of the Vedic poets, say about 1500 B. C., there existed a race of horses with only thirty-four ribs. Other zoölogists, and more particularly M. Sanson, raised some strong objections, but M. Piétrement replied to them in his "Mémoire sur les Chevaux à trente-quatre côtes des Aryas de l'Époque Védique" (Paris, 1871), and the question is still *sub judice.*

M. Piétrement's reasoning may best be given in his own words:

"In the first place, I would observe that the presence of only thirty-four ribs in an equine race, whether ancient or modern, would not be by any means abnormal, or contrary to the laws of Nature; for it is fully agreed now that the number of these bones is far from being constant in our present horses. Indeed, Chauveau remarks as follows on the number of ribs in the horse: 'We reckon for each lateral half of the thorax eighteen ribs. Not unfrequently we find nineteen, with an equal number of dorsal vertebræ in well-formed horses; but, then, most usually there are only five lumbar vertebræ.'

"On the other hand, we sometimes find in horses of a certain type 'only five lumbar vertebræ, instead of six (which is the usual number in the species *Equus caballus*), the number of the other vertebræ being the same as usual in the horse.'

"When this latter fact was published in France by M. Sanson, it at first met with much opposition, but now it is fully accepted by men of science; and it is justly considered as an indication of the ancient existence of an equine race with five lumbar vertebræ; and the crossing of these horses with horses having six lumbar vertebræ fully accounts for the frequent anomalies of conformation which we find in this region of the vertebral column."

Having by these considerations established the possibility of an ancient race of horses with only thirty-four ribs, M. Piétrement appealed for its reality to a passage in the most ancient literary document of the whole Aryan world, the "Rig-Veda."

The passage in which the thirty-four ribs of the horse are mentioned occurs in the 162d hymn of the first book of the "Rig-Veda Sa*m*hitā." I translated the whole of that hymn in my "History of Ancient Sanskrit Literature" (1860, p. 553). The hymn is ascribed to

Dīrghatamas, and describes the sacrifice of the horse in very full detail. In the eighteenth verse we read:

"The axe approaches the thirty-four ribs of the quick horse, beloved of the gods. Do you wisely keep the limbs whole, find out each joint and strike."

This passage is curious in many respects. It refutes the statement of Strabo (xv., 54), that the Indians did not slaughter their victims: "They do not slay the victim, but suffocate it, to the end that it may not be offered to the god mutilated, but entire." It also seems to imply that the horses then offered at the sacrifices had only thirty-four ribs. This statement, however, startled even the orthodox commentators in India, and Sāya*n*a remarks in his commentary on this passage, that other animals, such as goats, etc., have only twenty-six ribs, as might be proved by what he considers as far more convincing than ocular evidence, viz., a passage from the "Brāhma*n*as," in which it is said, "Its ribs are twenty-six." In another passage, in his commentary on the "*S*atapatha brāhma*n*a," xiii., 5, 1, 18, Sāya*n*a returns to the same subject, but unfortunately that passage, as edited by Prof. Weber, is so corrupt that I at least cannot make sense of it, though it is clear that Sāya*n*a says there that their ribs are thirty-six. Another commentator, Mahīdhara, explaining the horse-sacrifice, as prescribed in the "Ya*g*urveda," seems to have no anatomical misgivings, but states that the horse has thirty-four, goats and other animals twenty-six ribs.

I confess that I was myself very much puzzled by the passage in the "Rig-Veda." It was quite clear that the reading *k*atustri*m*sat, thirty-four, cannot be called in question; it was equally clear that that number would not have been mentioned except for some special purpose. That it was the habit of the ancient Hindoos to count the various bones of the human or animal skeleton, may be seen in the "Law-book of Yā*g*navalkya," iii., 85, *et seq.* There we read:

"The neck consists of fifteen bones, a collar-bone on each side, and the chin; two at its root, and the same on the forehead, the eyes, and the cheeks, and the nose of firm bone. The ribs with their supports and the Arbudas (*Zippenknorpel*) are seventy-two. Two front-bones, four skull-bones of the head, seventeen bones of the chest, these are the bones of a man."

Similar passages occur elsewhere, and establish the fact that the ancient anatomists of India made a point of knowing the exact number of the bones in the different portions of the bodies both of men and animals.

Not being able to find a satisfactory solution of my difficulty, I applied to Prof. Huxley, and I am glad, with his permission, to print the following letter, which offers a most ingenious, and, to my mind, satisfactory solution:

"26 Abbey Place, N. W.

"My dear Sir: I have been much interested in M. Piétrement's 'Mémoire.' His work 'Les Origines des Chevaux domestiques' is well known to me, but I

had paid no particular attention to his incidental mention of the 34-ribbed Aryan horse.

"M. Piétrement's essay raises three questions. The first, Does the passage of Dīrghatamas's hymn cited necessarily imply that the horse known to him had only thirty-four ribs? The second, Does the passage from Sāyana imply that he asserted of his own knowledge that the horses of his time (in 1400 A. D.) had only thirty-four ribs? The third, Are there any zoölogical arguments in favor of or against the existence of a breed of 34-ribbed horses?

"1. Your Latin version of the solitary Vedic passage upon which M. Piétrement relies, admits the reading, 'The axe cuts through [the] thirty-four ribs of the quick horse,' etc.

"I speak ignorantly, but suppose I am right in assuming that there is no more 'the' in the Sanskrit than in the Latin. Nevertheless, it is upon the presence of this definite article that the question turns. For, without it, the passage may simply mean that the axe cuts through thirty-four ribs out of the thirty-six with which the horse is provided. What makes me think that this may be the proper signification of the passage is the inquiry I put to myself, For what purpose did the sacrificing priest want to cut through the horse's ribs? Surely, in order to disembowel him. But, in order to do this, no one would go through the great trouble and labor of chopping through the bony parts of the ribs of a horse. Moreover, such a proceeding would be incompatible with the objection to mangling the horse's bones, which is strongly displayed elsewhere in the Vedic hymn.

"But every bony rib ends below in a gristly substance, and it is quite easy to cut these 'costal cartilages,' and then, turning them back, along with the breastbone, the cavity of the chest is laid widely open, and the priest readily reaches the heart or the like.

"But, if every rib ends in a cartilage, there must be thirty-six cartilages, and not thirty-four?

"True, but the last pair of ribs is much shorter than the others. It is not needful that all the thirty-six pairs of costal cartilages should be cut through in order to lay the chest thoroughly open; and for sacrificial purposes it may have been inconvenient to cut through more than the thirty-four ribs which lie in front of it.

"If you are laying open a man's chest for a *post-mortem* examination, you go to work exactly as I am supposing the Aryan priest to do. You cut through the rib cartilages on each side and take them away, along with the breast-bone to which they are attached. But, in doing this, you leave at least the last two ribs on each side untouched, because they are free, so that it is not needful to cut them.

"If I were a poet, and made a hymn about a *post-mortem* examination, I might speak of the operator's scalpel 'cutting through the twenty ribs,' without meaning to imply that the man of the period is devoid of his full complement.

"2. Does Sāyana say that the horses of his time had only thirty-four ribs? The passage quoted by you does not seem to me to bear that interpretation at all.

"3. As to the zoölogical aspect of the question. Horses may undoubtedly vary not only in the number of their ribs, but in the number of their dorso-lumbar vertebræ. The latter may be twenty-four (as usual), or twenty-three, as in the cases cited by Sanson, and also by Legh in his 'Handbuch der Anatomie der Hausthiere;' and the former may be eighteen (as usual) or nineteen on each side. Unfortunately, I know of no case on record (and M. Piétrement seems to

have been unable to find one) in which either horse, ass, or other equine animal, had *fewer* than thirty-eight ribs. If a 34-ribbed race of horses ever existed, I think it ought to turn up as a variety now and then. But it does not; and, what is still more to the purpose, we do not find that any of the immediate allies of the horse have fewer than thirty-six ribs; though they may, as in the case of the ass, have only five lumbar vertebræ.

"Without wishing, in the least, to dogmatize, then, I must say that the zoölogical probabilities appear to me to be dead against M. Piétrement's hypothesis; and unless you tell me that the Sanskrit text must mean that Dīrghatamas's horses had thirty-four ribs and no more, I shall take leave to doubt the existence of these 34-ribbed steeds.

"I am afraid I have troubled you with a very long letter, which does not come to much in the way of certainty after all. . . .

"I remain, yours very truly, T. H. Huxley."

I have little doubt that Prof. Huxley has solved the riddle. It is open to translate either the thirty-four, or thirty-four ribs; but, whether we adopt the one or the other rendering, it seems clear that the poet must have had some reason for mentioning that number. If thirty-four was the usual number of a horse's ribs in his time, then there seems little reason for giving the number. "Cut the ribs" would have conveyed the same meaning as "cut the thirty-four ribs." If, on the contrary, the number thirty-four was mentioned because it was exceptional, then the poet, and his commentators too, would have said more about the anomaly. Every thing becomes intelligible if we admit that, in cutting open the horse, two ribs were not to be cut, so that they might remain and keep the carcass together. In that case to mention the number of ribs that were to be cut had a purpose, though it is strange that tradition, which in India possesses such extraordinary tenacity in unimportant matters, should not have preserved the original purport of the words of Dīrghatamas. I have looked in vain for a passage where the cutting of the thirty-four ribs in the horse-sacrifice is more fully described; but I ought to add that in the oldest descriptions of the sacrifice of other animals, preserved in the Aitareya-Brāhma*n*a and the *S*rauta-Sūtras of Ālva*r*ayana, nothing it said of leaving two ribs undivided. "Twenty-six are his ribs," we read: "let him take them out in order; let him not spoil any limb."—*Academy*.

## GEOGRAPHICAL WORK OF 1874.

At the meeting of the American Geographical Society, held February 25, 1875, the annual address was delivered by Chief-Justice Daly, the President of the Society. Beginning with a brief survey of the remarkable physical phenomena of the year, including great falls of rain and snow, extreme and widely-distributed cold, earth-

quakes, volcanic disturbances, floods, cyclones, etc., he alluded, in passing, to the geography of the sea-bottom as made known by the recent examinations of the Challenger Expedition, and then took up the geographical work in our own country, as carried on by the United States Engineer Corps, and other explorers. The explorations of Lieutenant Wheeler show that every State and Territory west of the Plains is crowded with the products of volcanic action, ancient and modern, the connected beds of lava in Arizona and New Mexico covering an area of 20,000 square miles; and the conclusions of the geologists of the expedition are, that volcanic disturbances and eruptions in our Western territory will be resumed, and may occur at any day. They have occurred so recently, geologically speaking, that it is extraordinary there is no human record of them. In the Department of the Platte, a new route to the Yellowstone Park has been discovered by Captain Jones's exploring party. The Black Hills country was penetrated by General Custer's military expedition, and explored by Captain Ludlow. Prof. Hayden's geographical survey has confirmed the discovery of 1872, that Colorado is the great centre of elevation in the United States, having fifty peaks that are about 14,000 feet high. In the Pacific Ocean, soundings have been made for ascertaining a practicable route for a telegraph cable between Japan and Puget Sound, and for one from San Francisco to the Hawaiian Islands.

The separate researches and explorations of M. Pinvart and Mr. W. H. Dall, in Alaska and the Aleutian Islands, were next reviewed. M. Pinvart is of the opinion that the Esquimaux of this region are of the same stock as those of Greenland and Baffin's Bay, and concludes from their legends and traditions that they came originally from Asia across Behring's Straits. The probability of this conclusion is doubted by Mr. Dall; moreover, many American ethnologists think that Greenland and vicinity were peopled from Europe.

Prof. J. W. Putnam, of Salem, Mass., has been engaged in researches respecting the ancient inhabitants of North America. He believes that the southern Indians (the Mound-Builders of Ohio, Indiana, and other parts of the West) were not connected with the northern or eastern tribes, but were of the same stock as the ancient inhabitants of Mexico, though diversified by immigration and by mixing with other races.

In Central and South America specialists have carried on explorations in Costa Rica, Nicaragua, and the lower part of South America. A French expedition has been exploring Tierra del Fuego.

The arctic event of the year has been the return of the officers and crew of the Tegethof, of the Austrian expedition, and the important discoveries made by them. This expedition, in the difficulties it encountered, the perseverance displayed, the discipline maintained, and the success achieved, is about as heroic as any thing that has occurred

in the history of arctic exploration. The ship was frozen in off the coast of Nova Zembla from August till October, 1872, when the ice broke up, and they found themselves fixed upon an ice-floe helplessly *drifting*, but, strangely enough, to the *northward*. Drifting fourteen months in this way, mere passengers on an ice-floe, they were at last driven ashore and frozen in on a coast which they had discovered, but were unable to reach, two months before. This was in 79° 43′ north latitude, and 60° 23′ east longitude. It was now November, 1873, and they had passed the eightieth parallel. The long polar winter of 175 days set in, and the cold was so severe that the quicksilver remained frozen for weeks, and the darkness in midwinter was intense. The land, to which they gave the name of Franz-Joseph Land, was a most desolate region. In April, 1874, they set out in sledges and reached 81° 57′ north latitude, coming upon a country which they called Crown-Prince Land, whose cliffs were covered with thousands of ducks and auks; seals lay upon the ice, and there were traces of bears, hares, and foxes. Here, over a sea comparatively free from ice, they saw land in the distance, which seemed to stretch beyond the eighty-third parallel of north latitude. Their return-journey was one of over three months' hardship, make in sledges and boats.

In Europe, the long-projected measurement of an arc of the meridian was begun last autumn.

Archæological researches have been prosecuted in Dr. Schliemann's excavations of ancient Troy; and, while many doubt its identity, M. Emile Burnouf, Mr. Gladstone, the late premier, Prof. Keller, of Freiberg, and other eminent scholars, are of the opinion that it is really the city of Priam that has been discovered. But whether the site be Troy, or not, in the twenty thousand objects unearthed we have records which carry us back to the childhood of the world. The excavations in Pompeii show that only a small part of the city has as yet been opened. Every extension adds new objects, none of which are of more interest than its paintings; without these we would have been unable to judge of the excellence to which the Greeks had arrived in the art of painting; for, while their architecture and sculpture have endured, the paintings of their great masters have perished. In Rome, the excavations have disclosed many objects connected with ancient Roman life, public and private. In the tomb of a priest, the gold threads that were woven into his robe remained when every thing else had crumbled into dust.

An ancient Egyptian medical treatise has been discovered by Prof. Ebers, of Leipsic, which, by a calendar on the back of the papyrus, discloses that it was written 1,600 years before Christ.

In Asia, the geographical explorations and researches have, during the year, been numerous and widely distributed. The Sea of Aral has been surveyed, and found to be 165 feet above the level of the ocean, and 250 feet above the Caspian. The river Oxus, which empties into

it, has also been explored, revealing the fact that the country drained by the old river, whose channel is now dry, was the seat of an extensive civilization, of which nothing now remains but the ruins. Explorations have been made in the Himalaya Mountains, with a view to a railroad across Asia. The river Han-kiang, in China, hitherto almost unknown, has been found to be of great commercial importance. For the last four years the rich and prosperous country around Tien-Tsin, in China, has been lying under water from inundations to a depth of nearly five feet, and the unfortunate inhabitants of this once fertile region have been driven to seek new homes in the waste country north of the Great Wall. Many unknown regions have been visited by travelers and explorers, who found new countries, peoples, and customs. In the Kassia tribes, between Siam and Burmah, the doctrine of woman's rights is fully carried out. The women own the land, live in their own houses, do the courting, marrying, divorcing, and the lion's share of work; the men, being the weaker half, and not responsible for the maintenance of the family, do comparatively nothing, and take life easy!

A savage tribe, the remnant of a very ancient people, has been visited on the western coast of India. They are remarkable for their unswerving truthfulness. The women wear over their usual garment an apron of green leaves, the relic of an ancient custom, suggesting a passage in Genesis. In the central provinces the site of an ancient city has been discovered buried in dense jungles, and bearing inscriptions of two and a half centuries before Christ. The inscriptions are chiefly the records of donors of columns, like those seen in the gift-windows of our own churches.

In Palestine, Lieutenant Conder, R. E., has made important discoveries of ruins in the hill-country of Judah, which he thinks he can identify with some of the lost Biblical cities. He has found lost boundary-stones, which may prove to be the ancient Levitical landmarks. Discoveries have also been made upon Mount Zion.

At the mouth of the Persian Gulf there is a small island, of about twelve miles in circumference, called Ormus, or Hormus. Though a barren rock, it became, in the sixteenth century, from its geographical position, a place of great commercial importance and wealth, where the trade between Europe and the East was transacted. A town arose three miles in length along the coast and two miles in width. The Abbé Raynal describes it as presenting a more splendid appearance than any city in the East, and, he says, unusual opulence, an extensive commerce, the politeness of the men, and the attraction of the women, made it the seat of pleasure as well as trade. Milton refers to it in "Paradise Lost," where he describes Satan in council. Last year, Lieutenant Stiffo, of the British Navy, visited Ormus, and found that even its building-materials had been carried away, and that nothing remained of the once great and opulent city but a ruined minaret

about seventy feet high, mounds strewed with broken pottery, and a vast number of water-cisterns now choked with earth.

In Africa, Lieutenant Cameron, of the Livingstone Relief Expedition, has made an important discovery which fixes the source of the Nile within known limits, and which, there is every reason to think, will connect the net-work of lakes and rivers of the water-system that Livingstone was investigating, with the great rivers that flow to the western coast of Africa, and probably with the Congo. Livingstone and Stanley had settled the fact of Lake Tanganyika's being connected with Lake Albert N'yanza on the north by a river flowing into Tanganyika. The natives informed them that a river flowed out of Tanganyika at its southern extremity, which, if true, showed that Lake Tanganyika had no connection with the Nile. This outlet Lieutenant Cameron has found on the western side of the lake, about a third of the way up its length. He went into the river about five miles, when his boat was stopped by grass and rushes. The natives informed him that this river flowed into the Lualaba, the river that Livingstone had been following up when Stanley found him. From information got from the natives, Lieutenant Cameron believes that the Lualaba is connected with the Congo, and has started to ascertain the fact. If he should be successful, and return through the Congo to the western coast, it will be one of the most important geographical achievements ever accomplished in Africa. He ascertained the elevation of Lake Tanganyika to be 2,710 feet above the sea. Dr. Nachtigal has returned from an exploration of five years in Central and Eastern Soudan. He says the curse of the country he traversed is the internal slave-trade. It has depopulated large tracts, and the wretched fugitives are now driven to sell each other as a means of subsistence. He saw a caravan of 1,000 of these unhappy wretches chained, while they were driven to the distant market of Kuka on Lake Tchad, the drivers mercilessly cutting the throats of those who were, even under the lash, unable, from exhaustion, to continue their terrible march. The Libyan Desert has been explored and found to be the most sterile part of the Sahara, being a dried-up basin of a shallow sea below the level of the Mediterranean, the present surface of which was found to be a dry chalk plateau, like the Swabian Alps. A French expedition is making preliminary investigations as to the feasibility of M. Lesseps's project for creating an inland sea south of Tunis. The project is opposed by many familiar with this part of Africa, not only as useless, but it would have an injurious effect on the climate of the south of Europe, and also destroy the great source of wealth in this part of Africa, the cultivation of the date-tree. The existing commerce can be sufficiently carried on by caravans, so that the commercial results of the undertaking would never justify the enormous expenditure, which is estimated at £24,000,000. Along the western coast of Africa, explorations have been unusually active. Dr. Güssfeldt made a journey up

the Quilla River, and found a country reminding him of Switzerland. The west coast expedition for the relief of Dr. Livingstone give an interesting account of the region traversed. They found the natives civilized but indolent, and their attention was being given to the cultivation of the India-rubber tree, of the value of which the natives were previously ignorant. On the east coast Mr. Stanley has organized an expedition from Zanzibar at the joint expense of the *New York Herald* and the *London Telegraph*, to explore the region last visited by Dr. Livingstone. The French Marine and the Geographical Society will also send an expedition in the same direction. In Australasia, Prof. J. B. Steere, of the Michigan University, has, during a seven months' exploration in Formosa, gathered much valuable information respecting the island and its people. Interesting explorations have been made around New Guinea by H. M. S. Basilisk, and in Australia several remarkable journeys have been made across the country, through dreary regions and among natives in the lowest scale of humanity. A census of the island of Ceylon has been taken for the first time, and found to be 2,500,000; and in the course of the year the Feejee Islands, 312 in number, and covering an area of 8,034 square miles, have been annexed to the kingdom of Great Britain. The world is fully awake to the importance of geographical inquiry, and its thirty-five geographical societies watch the progress of the lonely traveler and self-sacrificing missionary, estimating their labor at its value, and welcoming every addition they make to the stock of human knowledge.

## WOOD'S DISCOVERIES AT EPHESUS.

EPHESUS, one of the twelve Ionian cities of Asia Minor, was famous in antiquity as containing one of the seven wonders of the world, the great temple of Artemis, or Diana. From very early times Ephesus was a sacred city; the fable ascribed its foundation to the Amazons, and the Amazonian legend is connected with Artemis. The first Ionian colonists in Lydia found the worship of the goddess already established here in a primitive temple, which was soon superseded by a magnificent structure. This Grecian temple was seven times restored, at the expense of all the Greek communities in Asia Minor. In the year 356 B. C. it was burned to the ground, but again rebuilt in a style of far greater splendor than before, the work extending over 200 years. This later temple was 425 feet long and 220 feet wide. "The foundations were sunk deep in marshy ground, as a precaution against earthquake," says Pliny. There were two rows of columns at the sides, but the front and back porticoes consisted of eight rows of columns, placed four deep. Outside, at the entrance

to the temple, stood a basin of porphyry, 15 feet in diameter, for the worshipers to lave and purify themselves in. The internal decoration was of the most sumptuous kind. The cedar roof was supported on pillars of jasper; the doors were of cypress. The altar was the work of Praxiteles, and it was surrounded by many statues, one

J. T. WOOD,
Fellow of the Royal Institute of British Architects.

of them of gold. The image of the goddess herself was roughly hewed out of wood, black with age, and greasy with the oil with which it was customary to anoint it. When the apostle Paul visited Ephesus in the middle of the first century, the worship of Diana still

flourished there, and the temple retained all its original splendor. Pilgrims to the venerated abode of the goddess used to buy little models of the temple in silver, or precious stones, as mementos of their visit, and as amulets to insure to them the protection of the Ephesian Diana. The Goths sacked the city and burned the temple, about 200 years later, and in the reign of Theodosius I., toward the end of the fourth century, the furious zeal of the Iconoclasts, or Image-breakers, completed the work of destruction. The ancient city almost entirely disappeared before the modern era, the very site of the temple being lost.

In 1863 an Englishman, Mr. J. T. Wood, while engaged as a civil-engineer in constructing a railway from Smyrna to Aidin, discovered at Ayasalouk the ruins of the Odeum, or Lyric Theatre of Ephesus, and this circumstance led him to commence excavations in that locality in search of the temple of Diana. He began his excavations on the west side of the ancient city, at a point where a long rise of ground above the level of the plain seemed to cover the portico of the temple. Here he found nothing but the remains of a Roman monument; so he went on digging trial-holes in every direction on the west side, and explored the great Gymnasium, which proved to be a Roman building, erected on the site of a former Grecian structure of similar character. On the surface of the ground, in the vicinity of this Gymnasium, were the remains of some columns of Egyptian silex. At some former time seven of these columns were carried away to Constantinople, and there set up in the church of Saint Sophia, now the Great Mosque. Hitherto they have been regarded as columns from the temple at Ephesus, but erroneously.

The plain has been filled up to the average height of about 15 feet. Digging in the agora, forum, or market-place of the ancient city, Mr. Wood found what he calls a baptismal font, the diameter of which is 15 feet. Its basin is 15 inches deep, and in the centre is an elevated pedestal, on which the minister of baptism might stand dry-shod, the postulants standing in the water. Other monuments of Christian antiquity were also discovered.

But there was yet no sign of the temple, and the literary remains of antiquity gave no indication as to its site. His private funds being now exhausted, the trustees of the British Museum were applied to by Mr. Wood for the means necessary to carry on the work of exploring the Odeum, or Lyric Theatre, in the hope of finding there some bas-relief, or other monument, or at least some idle scratching of a rough artist of the time, which might give some indication of the site of the great temple. In this hope he was encouraged by what he had years before seen in Venice and other places, viz., the plans of cities cut in bas-relief upon the pinnacles of the churches. The trustees of the British Museum having made the required grant of funds, Mr. Wood began the exploration of the Odeum. He found his way

into this theatre through the central doorway, and, on clearing the *pulpitum*, or stage, discovered on the pavement many small fragments of marble. These, on being put together, were discovered to contain inscriptions in Greek; they were the text of three letters of Antoninus Pius to the people of Ephesus, two dated A. D. 145, and one dated five years later. This theatre was 153 feet in diameter, and could seat 2,300 persons. Near it were found the remains of a tomb, which Mr. Wood takes to be that of the evangelist Luke; it was apparently a circular building, 50 feet in diameter, standing in a quadrangle 150 feet across, surrounded by a colonnade.

The exploration of the Great Theatre or amphitheatre began in February, 1866. This was one of the largest structures of its kind in Asia Minor, being 495 feet in diameter, and capable of seating 24,500 persons. Here were found many interesting Greek, and a few Latin inscriptions—chiefly decrees of the senate and people of Rome—and also some sculptures. One of these inscriptions, known as the Salutarian inscription, furnished to the persevering explorer the clew to the site of the temple. The inscription consisted of decrees relating to gold and silver images vowed to Diana by C. Vibius Salutarius. It is there prescribed that on certain days of assembly in the theatre these images were to be carried in procession by a priest of the temple, accompanied by a staff-bearer; and after the assembly they were to be carried back to the temple. Here was the desired clew to the site of the temple. "There were," says Mr. Wood, "two gates to the temple, named the Magnesian and the Coressian gates. It seemed to me that if I could find these gates their direction could not fail to point to the site of the temple. I at once searched for them, and in due time they were found."

In January, 1868, he put a gang of seventy men to work at the great theatre, and at the same time began to follow up the road leading from the Magnesian gate. This consisted of three openings—two for foot-passengers, and one for wagons and chariots. The pavement was intact, with four distinct chariot-ruts cut into it. Having followed up this road for about 700 feet, Mr. Wood came upon the stone piers of a portico 12 feet wide. This was undoubtedly the grand portico built by Damianus, a rich Roman noble. Many tombs were found, some of which were vaulted chambers finished in stucco or cement, and painted, and these had tablets over them. In some of the tombs were found several skeletons—in one as many as fourteen—lying in various directions. Next he hit upon a corner of the Peribolus wall, on which were inscriptions showing that this wall was built in the time of Augustus.

This was in May, 1869. The discovery of the Peribolus wall proved sufficient to induce the trustees of the British Museum to make further advances of money, and accordingly work was resumed in the October following. In the area within this wall, i. e., in the

sacred precinct of the temple, Mr. Wood sank a great number of trial-holes. Nothing of interest was discovered until the explorer had proceeded about half a mile from the angle first discovered, and then remains of Roman buildings began to be found. Soon he came to a long line of Roman buildings which must have been the dwellings of the priests and priestesses of Diana. He continued the explorations, searching for a similar range of buildings opposite, but found only one small building—a Roman temple. As this was not the Temple of Diana, he next began a search of the space between the buildings. This was found to be an open space, and the explorer conceived the idea that the temple must be in the rear of it; but in the mean time he found another building, and finally in the very last day of the year 1869 he hit upon the pavement of the temple itself, more than twenty feet underground. The main difficulties of the work were over: it was now a question simply of expense. The pavement was all beautiful marble. It was in two layers: the upper course in white marble, the lower one in cement, making altogether a thickness of two feet. At this stage the village of Ayasalouk was flooded by heavy rains, and the excavations were completely filled up with sand and water. When the water had subsided operations were resumed, and by October, 1870, there had been unearthed half a dozen of the large columns of the temple and fragments of one of the capitals, which had fallen over. One fallen column he traced to its base, and there ascertained that the same base had been employed in supporting columns in the last three temples. First of all we have the stone of the temple which was commenced 500 B. C.; this was used as the foundation of the column of the last two temples, one rising above the other.

In January, 1871, Mr. Wood bought the land over the temple for £160, and in less than a month afterward found, five feet beneath the surface, 2,600 coins of the fourteenth century, amounting in value to many times the price paid for the land. The British Government, in 1872, made a grant of £5,000 for the prosecution of the work, and another of £6,000 in the following year.

The discoveries on the site of the temple in the season of 1872–'73 comprised two large fragments of the frieze with human figures, life-size, in high relief, and the figure of a stag; the base of one of the inner columns of the peristyle; two sculptured drums of columns; some lions' heads, from the tympanum at the west end of the temple; a large fragment of a cedar beam from the roof, and a number of fragments from the last three temples. Numbers of Arabs came and pitched their tents near the excavations, and all the able-bodied men were employed on the works. The explorer's wife was of great service in caring for the health of these laborers and their families; sometimes she had as many as sixty patients under her care, without any doctor nearer than Smyrna.

Work was suspended in May, 1873, and resumed in October. During the season of 1873–'74, Mr. Wood made discoveries which enabled him to complete his plan of the temple. More than 100 feet of of the lowest steps of the platform were found in position in different parts; also a sculptured drum, with draped figures alternately seated and erect. At the beginning of 1874, Mr. Wood, having only a small balance on hand, applied to the trustees of the British Museum. He was allowed only a small sum, with instructions to close the work when it was expended. He therefore began to remove the cella walls, and found distinct remains of the last three temples. Part of the pavement of the temple destroyed by Erostratus was found in position, and also the altar at the east end of the *cella*, or shrine, which must have served for the three temples; also about 200 fragments of sculpture and architectural enrichment, of which the piers had been composed. Some of the sculpture was archaic. As Mr. Wood found several lime-kilns on the site of the temple, and large heaps of marble chippings ready for burning, we know what became of the works of Praxiteles, Scopas, and others.

On extending the excavation thirty feet beyond the lowest step of the platform a wide portico was found, which must have surrounded the temple on three sides, and also the remains of a Grecian Doric building, which could not be explored for want of funds. We have already stated that the foundations of the temple were laid in marshy ground, and Pliny says that this ground was prepared for receiving the foundation by having laid down upon it a layer first of charcoal, and then of *wool!* Mr. Wood makes no mention of this absurd statement of Pliny's, but says that, according to the usual account of the building of the temple, there was first laid a solid foundation of stone, and that upon this were laid charcoal and pieces of wood. To clear up the question, he made very careful excavations near the walls of the temple and underneath the wall, and found first of all a layer four inches thick, of a putty-like substance, very similar to glaziers' putty, both in constitution and appearance. Underneath this there was a layer of charcoal three inches thick. Then came a layer of putty four inches thick, making in all eleven inches, and upon this the walls of the temple rest.

# CORRESPONDENCE.

## CONSERVATION OF FORCE.

*To the Editor of the Popular Science Monthly:*

WILL you allow me to call the attention of scientists to some facts (suggested by me in the Monthly for February) inconsistent with the most important recent theory in physical science—the Conservation or Persistence of Force.

The persistence of force is as certain as the persistence of existence. But persistence being, so far, an absolute property or principle, cannot be proved by physical sense, or phenomena conditioned by mass, time, and space. Only finite relations are verified by finite proofs.

All things perceived through physical sense are, severally, quantitatively, and qualitatively, in unceasing change, and are, directly or indirectly, dependent on each other for their existence. Therefore, not phenomena, but only principles—things *per se*—persist. That the force or energy which we perceive, pressure, tension, or motion, does not persist, is not only a logical deduction from the nature of phenomena, but is a familiar fact in our experiences.

Force—pressure or tension—is created and annihilated at pleasure by the use of the lever.

Energy is evoked from motion, and motion is only changing relations in space, and as each specific or perceived change or movement is absolutely created and annihilated, not the *perceived* energy, but only the ideal, abstract principle, persists.

Again, the conservation of perceived force requires the existence of potential energy, or energy of position. But this "energy" is a misnomer; for mere position, or static relation in space, is in itself important, and therefore answers our conceptions of neither energy nor potentiality. Yet, it is alleged that the energy expended in lifting and planting a mass on the top of a mountain persists in the mass, because, *if it could fall*, that same energy would reappear. But it cannot fall. And its gravity being less, it has within itself, as a property, less falling force than before its position was changed by the expenditure of energy. To say, "If it had power to fall, it would *receive* the energy expended in lifting it," is equivalent to saying, "It does not possess that energy." If it imparted that energy to something else, from which it will be returned, to what did it impart it? If the ball in a loaded cannon has potential energy by being in front of the cartridge, what becomes of that energy when the powder is saturated with water?

Perceived force is conditioned by mass and relations in space, and, as here shown, change in these conditions changes its quantity. Physical science is limited to these conditions, changes, and quantities, because its verifications are limited to them. The proposition that a phenomenon persists, is a self-contradiction. Only objects of conception, and not of perception, persist.

The conservation of force is illustrated by that of form. If a circle of plastic material be changed to a square, abstract form persists through all the innumerable changes of size and form through which it passes, but no observed size or form persists; *nor is any specific form, from the circle to the square, metamorphosed into its subsequent form;* each is as absolutely created and annihilated as though there were no persistence of form.

And, as matter is only a concrete of properties, and as form is as persistent as other properties, it follows that all perceived physical changes are creations and annihilations. What is observed as gas is not the persistent thing *per se*, but only one evanescent state of that which persists. Hence, this perceived thing, gas, is no more metamorphosed into its subsequent water, than a circle is into a square. All that was observed—gas—was as totally annihilated, and what appeared—water—as surely created, as were the circle and square. No perceived physical property persists, for, even the alleged physical proof of the per-

sistence of matter—weight—is annihilated and created by distance and proximity to the earth.

Physical science relates only to the limited and conditioned, because its proofs are limited. The unlimited—persistent—is beyond the realm of physical sense and experimental proof. Hence, only abstract, ideal force persists, and is known to persist, not from our experiences with perceived forces, but only because mind, heredity, and mental experiences, evolve the conception of ultimate, absolute principles, and forbid the conception of their annihilation.

Proper discrimination, exactly expressed, between perceptions of the finite and conditioned, and conceptions of the persistent and absolute, rids science from the odium of materialism, and other fallacies, and makes the persistence of force not a new theory, but what it was ever conceived to be—the principle of potency—causality—an attribute of the ever-existing I Am.

Alleged infallibility of spectrum analysis of suns and nebulæ, billions of miles distant, when, for terrestrial use, the Director of the United States Mint says, "it cannot be trusted," shows the present tendency to sacrifice logical mental conceptions to mere physical sense.

Religious superstitions, in their conflict with science, will not succumb to sophistry: but, let scientific, physical facts be fortified with careful experimental verification, and hypotheses with pure logic, and give mind, though it be "discerned in matter," its fair share of the universe, and both superstitious bigotry and fallacious dogmas will surely disappear.

A. Arnold.

Tenafly, N. J., *February* 20, 1875.

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# EDITOR'S TABLE.

## *DRAPER AND HIS CRITICS.*

DR. DRAPER has reason for gratitude to his friends, and doubly so to his enemies. He wrote a bold book upon a subject never before separately treated, and by a large portion of the press it has been received with favor as a valuable and important contribution to the serious thought of the time. The interest in the subject, the reputation of its author, and the cordial commendation of many critics, were certain to secure the work a fair measure of success; but, on the other hand, a considerable number of writers were enraged by it, and, with the usual folly of passion, have execrated it into about thrice the circulation that it would otherwise have had. It is to be hoped they will learn that things are often overruled, in this world, to ends not contemplated by their contrivers. This, however, lends no excuse to bad practices, and those who have unscrupulously attacked Dr. Draper's work are to be held to account for it, just the same as if they had not overreached themselves in the result aimed at.

The honest and intelligent criticism of his book will, no doubt, be respected by its author, and objections to its reasonings and conclusions will probably be taken into careful consideration; while, if convinced of their validity, he may be expected to indicate it in future editions of the volume. But by a very considerable portion of the religious press, and by many secular journals, the editors of which know where to flatter and where to abuse, with a view to brisk sales, the book has been vehemently denounced. *Scribner's Monthly*, for example, published in March an admirable article on the "Indecencies of Criticism," and the same number contained a "criticism" of Dr. Draper's work, illustrating them so perfectly as to raise the suspicion that such was its design. The frothy invective that has been copiously poured out under the name of criticism is, of course, not worth noticing; nor shall we trouble ourselves with the various petty objec-

tions that have been raised, and that are so easy to raise, against a work of this character. But one criticism, particularly, deserves attention, because it lies against the whole reason and purpose of the book, and has been made on all sides; in fact, it forms the only unanimous basis of attack on the part of Dr. Draper's assailants. It is said that his work is a fiction, and represents no reality; that his subject is an illusion, his title a misnomer, and his book a mere figment of the imagination. He professes, it is said, to write a "History of the Conflict between Religion and Science," when there is not, and never has been, any such real conflict, and therefore no possibility of its history. The organs of all the orthodox denominations are in emphatic accord upon this point, and even the outside sects—Jews, Unitarians, and Catholics, whom the orthodox repudiate as beyond the pale of Christianity, as knowing nothing of true religion—take precisely the same ground in regard to Dr. Draper's work. The *Jewish Times*, for example, says: "Is there really a conflict between science and religion? We answer emphatically, no! There is no such conflict! there can be no such conflict!" Dr. Thomas Hill, in the *Unitarian Review*, says of Draper's book, that "so far from giving us a history of the conflict between science and religion, it gives us nothing to show that such a conflict ever existed;" and Dr. Brownson, at the Roman Catholic extreme, declares of our author's volume, "He professes to give in it the history of the conflict between religion and science, or of a conflict that has never occurred, and never can occur." There is, at all events, little conflict here, but an harmonious strain of denial of the legitimacy of Dr. Draper's subject, all along the line, and which reaches even to the dubious borders of that which is recognized as no religion at all.

What, now, are we to make of this? It can hardly be that these diverse parties have solemnly conspired to perpetrate a huge joke; and we can only suppose that they are serious at the expense of their intelligence. Religion and science have certainly coexisted in the world for a long time, and they have both figured pretty largely in human thought and human affairs. They must have had some relations with each other, and these relations must have had a definite character. If they have not been in conflict, then they have been out of conflict, or in harmony. Those who deny the antagonism must affirm the opposite, or that the relations of religion and science are, and always have been, those of concord and harmony. But, if this be so, let it be understood that Dr. Draper's work is not the only one that is discredited. What means the multitude of books that have been written professedly to bring these subjects into harmony? There is a vast body of theological literature, going back for centuries, that is devoted to the work of *reconciling* religion and science. Whole libraries of such literature have been consecrated to the harmonization of separate and special phases of that relation. Generation after generation have spent a large part of their theological force in reconciling Christian doctrine which has been held as religion, with astronomical, geological, biological, and ethnological science. If Dr. Draper is a romancer, then all this must also go to the account of romance. If there has been no conflict, then there could be no reconciliation, for the attempt to reconcile that which is already harmonious is absurd. If it be said that our ignorant predecessors may have fancied a hostility which we now know to be unreal, the reply is, that the work of reconciliation was never so rife as to-day. We could run THE POPULAR SCIENCE MONTHLY alone on the papers we receive from the theological side, aiming to harmonize present religious thought with the

present condition of science. Why this vigorous and comprehensive effort to harmonize the already harmonious? The religious periodicals abound in discussions aiming to compose the alleged differences and discords of religion and science; and there pours from the press a continuous stream of books devoted to the same end. An impending volume of eight hundred pages is announced by a correspondent of the *Evening Post*, who gives an analysis of its contents, and remarks: "The conflict between science and religion as to man's origin on this planet has been so ardent, and the interest which men of culture the world over feel in the subject is so deep and growing, that I can hardly be mistaken in supposing that the readers of the *Evening Post* will be pleased to receive a synopsis of Mr. Southall's book, the proof-sheets of which I have been kindly permitted to examine. He combats the views of Lyell, Lubbock, Evans, Lartet, De Mortillet, Nillson, Worsaae, Désor, and others, that man is several hundred thousand years old, or, as Mr. Geikie and Mr. Boyd Dawkins, in their recent books put it, preglacial." Again: "The book will provoke a deal of criticism in scientific and religious circles. Persons far more competent than the present writer to pronounce judgment upon its merits, do not hesitate to say that it is the most important contribution yet made in America to the theological side of this weighty subject." Of course, "the theological side," which holds that there is no such thing as "the conflict between science and religion," "ardent" or otherwise, will at once proceed to squelch this superfluous writer; and when they have done so, and repudiated the folly and futility of all other books of the same class, and dried up the discussion in their periodicals, it will be time to talk to Dr. Draper about the illusiveness of the subject-matter of his history. There is something not a little ludicrous in the attitude of those who are lustily continuing a fight that is centuries old, and, when the history of it comes to be written, suddenly turn non-resistants, and protest that it is all a mistake, and that there has really never been any conflict at all! Can it be that it is because they would rather not have the history appear?

But it will be said that truth can never be in conflict with itself; that religious truth and scientific truth *must* harmonize, and that any apparent antagonism is due to prejudice and imperfect knowledge. Granted; but this concedes the fact of a conflict, and only proposes a theory of its cause. The harmony affirmed is not a harmony realized, but rather hoped for, as a possibility of the future, to which present broad and thorough investigation is tending; and with this we entirely agree. But the hope of a state of things yet to be reached cannot be made a ground of denial of what is, and has been. It is maintained that, at bottom, there is no real conflict between capital and labor, and many indulge the anticipation that their relations will be ultimately harmonized; but he who denies that there is now any such conflict had better spend a few days in the mining districts of Pennsylvania, where for months this conflict has threatened the peace of society. It is also held that the true and highest interest of nations is that of concord, and many think that the world will yet grow into international amity and unity; but shall we therefore deny the past existence of war, and discredit as groundless all our histories of international hostility? The case of religion and science is exactly parallel. However they may finally be brought into accord, they certainly are not in that relation now, and no antagonism of the past has been more deep and unrelenting, and more defiant of all efforts at adjustment, than this. The conflict between religion and science,

or between the study of Nature and the tracing out of its order, and the systems of belief that claim a religious character, is as much a reality of human experience as the collisions of nations, and just as much a proper subject for the historian.

Dr. Draper has been much reproached for not defining what he means by religion. There is no complaint that he has not defined science, because no need of it is felt; everybody understands what science is. But it is not so with religion. The theological world is full of dispute and contention as to what religion is. It is loudly declared by the theological party that science and religion are in harmony, and then the theological groups fall straightway to battling over the initial question as to what constitutes religion! Each group assumes it to be what its members believe, and what those with different beliefs do not possess. The reverend representative of the Unitarians, Dr. Hill, says of the oldest and most numerous Christian communion: "The hostility of this corrupted Church toward science was no greater than its hostility to religion; religion and science, twin forms of truth, were alike persecuted by this dragon; and it is both an injury and insult to Religion to ascribe to her the evil deeds of those who hate her, and wore her name simply as a cloak for their political ambition and their intolerant pride. For every martyr of science, history can show a thousand martyrs of religion slain by the ecclesiastical powers of Rome." But the representative of the "dragon," at the opposite wing, is ready with his reply to this Unitarian Gentile. Dr. Brownson says: "Christianity teaches that Gentilism is apostacy from God and from his truth, and that so far from being his worship it is the worship of devils. We protest, therefore, against the logic that concludes that what it finds true of Gentilism is and must be true of Christianity. We protest also against concluding that, because Protestantism is a congeries of absurdities, Catholicity is unreasonable and false. Gentilism and Protestantism may stand in the same category or be simply varieties of the same species; but they are specifically, generically different from Christianity." And between these two extremes there is a crowd of sects which agree in little else than in dismissing the Catholics and Unitarians to perdition as destitute of all religion! Dr. Draper, it is evident, would have complicated his case to little purpose had he gone into definitions, and thus virtually assumed to decide, among these conflicting claimants, which has the true religion. For historical purposes Dr. Draper was compelled to take broad views, and to recognize as religious all bodies of people who combine and organize for religious ends, profess religious faith, and make claims to religious character, giving prominence in his treatment of the subject to those who have been historically most prominent, and are most responsible for theological resistance to the reception of scientific ideas.

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### *WITH REFERENCE TO SPELLING.*

The severity of the spelling-school contagion is manifestly abating. This is well, for we are told that public excitements are dangerous to reason, intense and prolonged spasms, religious or social, generally ending in a new accession of recruits for the lunatic asylum. It is an interesting question what degree of fervor, extent, and duration of spelling-matches would be required to reduce the general mind to a condition of imbecility. Life is full of contradictions, and we can rarely go a mile with our logic: to misspell our language is a sin, while to reach the height of orthographic virtue may involve intellectual suicide.

We recollect a wave of excitement

that passed over us a few years ago in relation to spelling, a feature or two of which may be worth recalling. A veteran school-teacher of New York dropped a hurried line to a newspaper, in which two or three words were wrongly spelled. It was a dull season for news and excitement, and so, in its enterprise, journalism sat on this old party, and his life was darkened. He has since gone to that undiscovered country where it is to be hoped that Webster and Worcester have never been heard of; but he has left us struggling with the beggarly elements of a barbarous orthography, and no better off for the storm of reproach to which he was a martyr. His fellow-teachers came to the rescue with indignant letters to the editor, and that remorseless personage published them, bad spelling and all, every time. "Behold," said he, "the state of American education, when its masters are unable to spell their native language!" There seemed no question that the highest achievement of the human mind was to put letters together in exact accordance with some authority; and that to drop or transpose a letter, in the tens of thousands of their arbitrary combinations, that form the words of our language, was an offense that should consign its perpetrator to everlasting ignominy. The thing was all going one way until there arose a rebellious voice in the East, which said to the editor: "Let me take advantage of the present spelling excitement to fatten a grudge I bear against the literary world." The soul that had been thus stirred to utterance was that of Elizur Wright, and he went on, in his pungent way, to say: "A school-master who does not spell correctly by somebody's system should go abroad and stay there. But just here it is that my indignation kindles. Why do we have these illiterate school-masters? I do not stop to blame weak or careless committees: the trouble lies higher. The great masters of English literature, the lawgivers of our language, are such bunglers or charlatans in their own profession, that they ought to be ashamed to fling a pebble at the worst of spellers, or even at the inventor of Egyptian hieroglyphics." After venting his wrath upon the conservators of the present "imperfect, unreasonable, stupid, false plan of visualizing the vocal tongue," he thus proceeds:

"The misery of the matter is, that it is difficult to get any but blockheads to teach such a blockhead system. We do uncommonly well when we get hold of pedantic dunces who can teach spelling with a vengeance, and perhaps the shell of grammar. Of course, I do not deny that there are some literary saints, of unquestionable genius, who devote or doom themselves to a painful inculcation into the memories of reluctant or rebellious youth of all the incongruities, contradictions, riddles, and sphinx-puzzles of English orthography." And again: "English orthography is congenial only with stupidity; and, after thirty or forty years of occasional observation in regard to it, I am of opinion that good and successful teachers of spelling can seldom write a page without misspelling several words."

And this is the writer's significant climax: "Of another thing I have no doubt at all, to wit, that learning to spell is a discipline pernicious to good mental habits. The minds of unschooled children are eager for facts and the reasons of them; and they are not satisfied with a reason till they see its force. But, after they have been schooled through the inconsequential mysteries of the spelling-book, where a reason has less chance of living than a mouse in a vacuum, they are ready to swallow any thing the book or the teacher says, with a leaden quietude. No thanks to the portico of our literature, if they do not continue to take things on trust, as long as there is any thing to be so taken."

There is a truth in these last remarks which deserves from educators a great deal more serious attention than it has yet received. No one will deny that our spelling is irrational; and, if so, just to that degree the art of spelling is an irrational practice; that is, it is a practice which, in the first place, calls for no exercise of the reasoning faculty; and, second, it is an exercise which continually violates the dictates of reason. The pupil who should spell a word as reason dictates would be flogged, or in some other way disgraced before the school. On the other hand, the pupil that can bring his mind into the most perfect harmony with an irrational system, can go on perpetrating absurdities the longest without failing, wins prizes and applause. This certainly cannot conduce to good mental habits. The child is born into a world of real objects and relations, and the mind grows through experience in acquiring ideas of these actual things. Discrimination, comparison, inference, reasoning, judgment, are all elements of early mental activity, and, in fact, constitute the intellect. Mental growth consists essentially in strengthening and extending these operations on newly-acquired and newly-combined ideas. These rudimentary processes of the infantine intellect are of exactly the same nature as the perfected processes of scientific and philosophic intellects; and it is the true office of education to lead them out, or guide their unfolding from lower to higher states. Written language must be called in at an early stage, as an indispensable help in this upward progress. Yet, such is the imperfect character of this new instrument, and such the bungling of many who teach its use, that the child is quite as apt to be hindered and stopped by it, in its mental course, as helped on. Nay, when we remember that this is the most critical stage of mental unfolding—the taking of the child out of Nature, as far as that can be done, and immersing it in the school where irrational mental practices are arbitrarily enforced—it is no exaggeration to say that more mind is extinguished than is led out, and that the school-room is as liable to become a mental slaughter-house of the innocents as a place of healthy education. When a child enters school, there should be no break in its earlier mental unfolding; but this is just what generally occurs. Instead of going on with its normal mental exercises, it is turned off into artificial mental exercises. Instead of still employing its thought mainly upon the properties and relations of things, symbols are substituted for things, and the whole action of the mind becomes a manipulation of symbols. The memory is not only loaded with verbal signs, but these are arbitrary and contradictory; and an accuracy is exacted in retaining them which consumes an immense proportion of the time, and, after working great mental mischief, generally ends in failure. Tolerable spelling is, of course, an important thing, but we do not believe in dwarfing or stupefying the mind to gain it. Let it be taught incidentally, and in subordination to the regular exercise of the higher faculties, and the end will be better served than by trying to make it the prime accomplishment of education. Perhaps, in regard to so fundamental a reform, but little is to be expected from the present generation of teachers; but, happily for the hopes of humanity, there is an arrangement by which the present generation of teachers is destined to be taken out of the way.

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## LITERARY NOTICES.

English Men of Science; their Nature and Nurture. By Francis Galton, F. R. S., etc. New York: D. Appleton & Co. London: Macmillan & Co.

The author of this book is quite widely known by his former publication, "Hereditary Genius," and by various statistical

works. Here he has attempted to analyze the "Natural History of the English Men of Science of the Present Day," and to determine, if possible, the effect of the circumstances in which they have lived, including the consideration of their antecedents, their hereditary qualities, their education, and of the influences which have made them what they are.

His definition of a man of science, for the purpose of his inquiry, is characteristically English, although it may be, on the whole, the best attainable one for the special questions of which he treats; he selects, then, only members of the Royal Society of England, and among these he still further separates those who have received a medal for scientific work; those who have presided over a section of the British Association for the Advancement of Science; those who are members of a certain literary and scientific club of London, etc., etc. On these grounds 180 men have been selected, who are presumably representative English scientific men.

The author estimates that at least 300 men could have been selected, and that this gives (having regard to age) about one scientific man to every 10,000 in England.

His question then is, "What are the conditions of nature and the various circumstances and conditions of life—which I include under the general name of nurture—which have selected that *one* and left the remainder?" The data available for the solution of this question are "the autobiographical replies to a very long series of pointed questions addressed severally to the 180 men" previously described. Of course, these replies were given in confidence, and it is not possible for the reader to connect the various replies, which are often given in detail, with any one person interrogated.

The first inquiry is into the "Race and Birthplace" of the subjects of the inquiry. Out of ten scientific men, five are pure English, one pure Scotch, etc.; their birthplaces are usually in towns away from the seacoast. "The branch of science pursued is often in curious disaccord with the surrounding influence of the birthplace. Mechanicians are usually hardy lads, born in the country; biologists are frequently pure townsfolk."

The occupation and position in life of the parents are next considered, and the chief point of interest here developed is that, out of every 100 scientific men, only three or four have had clergymen for their fathers. Although so many of the graduates of the English universities take holy orders as a means of securing fellowships, yet it is noteworthy that, in a fairly-selected list of 660 separate appointments on scientific councils, only sixteen have been divines, and these have chiefly been proficients in the astronomical and mathematical sciences, and not a single biologist is to be found among them. The inquiry proceeds to physical peculiarities of parents, and the conclusion is reached that out of 165 cases examined these peculiarities were in *harmony* seventy-eight times, in *contrast* thirty-one times; from examination of special conditions, such as the height, color of hair, corpulency of the parents, the general result is that the parents of scientific men are decidedly more in harmony as to their physical characteristics than in contrast.

In some of these discussions we confess to a slight feeling of doubt as to the trustworthiness of the conclusions. Although "figures will not lie," there may be an accidental accumulation of coincidences in a small number of cases which will quite mask the real law, and statisticians need excessive care in drawing such conclusions.

In general, this caution is evident throughout the volume. We have given enough to elucidate the author's method; and we will only note those conclusions which seem most interesting, referring the reader to the book itself for details.

The average number of living children of scientific men seems to be, on the whole, decidedly smaller than that of the parents of these men; their health relatively to their parents is not so good; in one out of every three cases their marriages are sterile. In contrast to this, it may be said that their health, relatively to that of the average man, is better and their energy greater. Still the conclusions above noted do not promise well for the continuation of the race as pure blood.

Chapter II. deals with the qualities of the men themselves, as derived from their answers to the questions proposed to them.

Out of every ten, "seven call themselves members of the Churches of England, Scotland, or Ireland," while the remaining three are distributed among various sects; two out of every ten have a "decided religious bias."

To the question "Has the religious creed taught you in your youth had a deterrent effect on the freedom of your researches?" seven or eight say "No" to one who says "Yes."

Chapter III. deals in an admirable manner with the "Origin of the Taste for Science," and we commend it to all who are interested in scientific education; together with Chapter IV., which deals with the merits and demerits of the education itself.

The lessons of these two chapters are condensed by the author into this general statement: *Teach a few congenial and useful things very thoroughly; encourage curiosity concerning as wide a range of subjects as possible; and do not over-teach.* Specially he recommends (from the knowledge gained from his inquiry), for the precise subjects to be studied in order best to educate a youth for scientific pursuits: 1. Mathematics; its processes to be utilized for interesting ends and practical application; 2. Logic; 3. Observation; theory in experiment in at least one branch of science; 4. Accurate drawing of objects connected with this branch; 5. Mechanical manipulation. "These five subjects should be *rigorously* taught." There should remain enough time for literature, history, poetry, and languages: these last are to be learned solely to enable the learners to read ordinary books written in them.

Most of these conclusions are quite as applicable to America as to England, and they deserve the most careful attention.

Roughly speaking, the author finds that "six out of every ten men of science were gifted by nature with a strong taste for it," and "we may therefore conclude that the possession of a strong special taste is a precious capital, and that it is a wicked waste of national power to thwart it ruthlessly by a false system of education." No test can be given to distinguish in the youth a special taste from a passing fancy, but hereditary inclinations should be carefully regarded. A curious result of the inquiry is, that the influence of the father in determining the scientific taste is three times more potent than that of the mother. Probably the general impression on this point is opposed to such a conclusion.

The practical lesson for England is drawn with great force and skill by the author on page 222, *et seq.* Much of this is inapplicable to us in America, but it is in the highest degree valuable generalization, and it is peculiarly worthy the attention of educators.

Science with us is sporadic, and no one is in any degree directly responsible for its fostering, except, perhaps, the larger universities. There is no central power which can assist its prosecution, nor is there much intelligent inclination on the part of our lawmakers to help it or hurt it. As an example of the lack of intelligence in the forwarding of scientific research, we may note the liberal appropriations ($175,000) for the observations of the transit of Venus by the last Congress but one; and the refusal of more than $3,000, by the last Congress, for the preliminary computations incident thereto. Evidently for us at this time the lessons of this book are not to be applied, but much more elementary ones; yet, undoubtedly, the true principles of "government aid to science," and of the "endowment of research," are correctly indicated.

These are questions which assuredly will arise in America as they have in England, and we cannot doubt that the careful analysis here given will serve as a firm basis for rational action in this most important direction.

The Heart of Africa: Three Years' Travels and Adventures in the Unexplored Regions of Central Africa, from 1868 to 1871. By Dr. Georg Schweinfurth. In two volumes. Price, $8. Harper & Brothers.

This is a model book of travel, fresh, entertaining, full of novelty, yet in a high degree instructive and trustworthy. Its author combines the accomplishments of the artist with the solid acquirements of the man of science and the ardent enthusiasm of the explorer, so that, though still a young man, his name is already famous both in Europe and America. The history of Dr. Schweinfurth happily illustrates the power

of early impressions. At his first school one of the masters was the son of a missionary in South Africa. The stories he told of the wonders of that distant country took possession of the youthful fancy of his pupil, and turned his mind toward the land where he was to achieve such signal renown. Dr. Schweinfurth devoted himself from boyhood to the science of botany. He studied at Heidelberg and Berlin, where he took his degree as doctor of philosophy. In 1860, when about twenty-four years of age, his interest in Africa was intensified by the circumstance that a collection of plants from the region of the Nile was placed in his hands to arrange and describe. While engaged in this work, a yearning came over him to behold these plants in all their bloom and beauty in their native haunts, and so added an immediate stimulus to his life-long interest in that strange country. Accordingly, in 1863 he left Berlin for Egypt, and, after botanizing in the Delta of the Nile, along the shores of the Red Sea, in Abyssinia and Khartoom, for two years and a half, he went back to Europe with an empty purse and a splendid collection of plants, though obtained at the additional cost of repeated attacks of fever. But this expedition only whetted his appetite for African exploration, and he soon submitted to the Royal Academy of Science a plan for the botanical survey of the equatorial districts lying west of the Nile, portions of which were still wholly unknown. His proposals were accepted, and the expenses of the enterprise were met by the "Humboldt Institution of Natural Philosophy and Travels," in Berlin. In July, 1868, he again landed in Egypt, and in the first chapter of this work he records the incidents of his journey till his arrival at Khartoom. After a short delay he proceeded up the White Nile and Gazelle. He says:

"In the early morning of the 22d of February we found ourselves at the Meshera, the landing-place of all who resort to the Gazelle. . . . Deducting the days on which we had not proceeded, our boats had been thirty days in going from Khartoom to the Meshera. I had been anxious to make a good investigation of the river-banks; otherwise the voyage might easily be accomplished in twenty days."

As a result of this study, several pages are devoted to explanations of this river system and the topography of the swampy region of the Meshera, where he was compelled to linger through February and March, botanizing in swamps, wading among papyrus-clumps, and exposed to the dreaded malaria of this unhealthy region. His immunity from sickness he attributes in part to the three doses of quinine, of eight or nine grains each, which he took daily. Half the travelers who have ventured into these swamps have succumbed to fever. Here Miss Tunné's expedition suffered a loss of five out of its nine European members, and among them Dr. Steudner, the botanist of the expedition. Here Heuglin lost most of his time by continual relapses of fever. And in this region Le Saint, a French geographical explorer, had died a few months before. From this place he took his start for the interior. He thus describes his company:

"The number of our caravan was a little under 500. Of these the armed men amounted to nearly 200, and constituted a force with which we might have crossed the largest state of Central Africa unmolested. Our course for six days would be through a notoriously hostile country, so that this precaution was quite necessary; but the caravan, extending fully half a mile, was of a magnitude to require great order and circumspection. . . . To a naturalist on his travels, the employment of men as a means of transport appears the perfection of convenience. Apart from the dispatch and order in starting, and the regular continuous progress, he enjoys the incalculable advantage of being able to reach his baggage at any moment, and to open and close again, without loss of time, any particular package. Any one who has ever experienced the particular annoyances of camel-transport will be aware of the comparative comfort of this mode of proceeding. A few asses accompanied the caravan, and the Governor of Ghattas's Seriba had been courteous enough to send me his own saddle-ass, but I preferred to trust myself to my own legs. Riding a badly-saddled donkey is always infinitely more fatiguing to me than any exertion which may be requisite to keep up with the forced marches of the light-footed Nubians; besides, I had other objects in view than mere progress; I wished to observe and take notes of any thing that came in my way, and to collect plants and whatever else might be of interest. Thus, entirely on foot, I began the wanderings which,

for two years and three months, I pursued over a distance of more than 2,000 miles. Neither camels nor asses, mules nor horses, teams of oxen nor palanquin-bearers, contributed their aid. The only animal available, by the help of which Central Africa could be opened to civilization, is exterminated by fire and sword: the elephant is destroyed mainly for the purpose of procuring for civilized nations an article wherewith to manufacture toys and ornaments, and Europeans still persevere in setting the savages a pernicious example in this respect."

After passing through the lands of the Dinka, Dyoor, Bongo, and Mittoo, and adding much to our knowledge of these people while studying the topography of the country and contributing important discoveries concerning its river system, besides his incessant botanical, entomological, and meteorological observations, he came upon the territory of the Niam-niam. On the 29th of January, 1870, he set out with four Nubian servants, and thirty Bongo bearers, under the protection of Mohammed Aboo Sammat, a magnanimous Nubian merchant, who, sword in hand, had vanquished various districts large enough to have formed small states in Europe. Of this man the author says:

"Not only throughout the period of eight months did he entertain me and my party in his settlements, seconding all my wishes, but when I desired to explore outlying parts, he lent me the protection of his armed force. Solely because I was supported by him did I succeed in pushing my way to Upper Shary, more than 800 miles from Khartoom, thus opening fresh districts to geographical knowledge and establishing the existence of some enigmatical people. Every thing that Mohammed did was suggested by his own freewill. The purest benevolence prompted him—the high virtue of hospitality in its noblest sense."

They were soon joined by a caravan consisting of 500 bearers and 120 soldiers, and these with women and slaves made a procession in single file of some 800 people. The incidents of their progress are of the deepest interest, but we have no space for their enumeration. From his account of the Niam-niam people we quote the following:

"The social position of the Niam-niam women differs materially from what is found among other heathen negroes in Africa. Whenever I met any women coming along a narrow pathway in the woods, or on the steppes, I noticed that they always made a wide circuit to avoid me, and returned into the path farther on; and many a time I saw them waiting at a distance with averted face, until I had passed by. This reserve may have originated from two opposite reasons: it may, on the one hand, have sprung from the more servile position of the Niam-niam women themselves; or, on the other, it may have been necessitated by the jealous temperament of their husbands. It is one of the fine traits of the Niam-niam men that they display an affection for their wives which is unparalleled among natives of so low a grade, and of whom it might be expected that they would have been brutalized by their hunting and warlike pursuits. A husband will spare no sacrifice to redeem an imprisoned wife, and the Nubians, being acquainted with this, turn it to profitable account in the ivory-trade. They are quite aware that whoever possesses a female hostage can obtain almost any compensation from a Niam-niam."

Between the parallels of 3° and 4° north latitude, and 28° and 29° east longitude from Greenwich, in the very heart of Africa, is a territory of some 4,000 square miles, inhabited by the Monbuttoo. The country of the Niam-niam constitutes its northern and northwestern boundaries:

"This land," Schweinfurth says, "greets us as an Eden upon earth. Unnumbered groves of plantains bedeck the gently-heaving soil; oil-palms, incomparable in beauty, and other monarchs of the stately woods, rise up and spread their glory over the favored scene; along the streams there is a bright expanse of charming verdure, while a grateful shadow ever overhangs the domes of the idyllic huts. In the deeper valleys, trees grow to such a prodigious height, and exhibit such an enormous girth, that they could not be surpassed by any that could be found throughout the entire Nile-region of the north. Beneath the imposing shelter of these giants, other forms grow up, and, rising one above another, stand in mingled confusion."

From his account of the Monbuttoo, of whom he speaks "as exhibiting a development of indigenous culture entirely different to what can be witnessed all around," we quote the following:

"The two sexes conduct themselves

toward each other with an excessive freedom. The women, in this respect, are very different to the modest and retiring women of the Niam-niam, and are, beyond measure, obtrusive and familiar. Their inquisitiveness was a daily nuisance: they watched me into the depth of the woods, they pestered me by flocking round my tent, and it was a difficult matter to get a bath without being stared at. Toward their husbands they exhibit the highest degree of independence. The position in the household occupied by the men was illustrated by the reply which would be made, if they were solicited to sell any thing as a curiosity: 'Oh, ask my wife; it is hers.' Their general demeanor surprised me very much when I considered the comparative advance of their race in the arts of civilization. Their immodesty far surpassed any thing that I had observed in the very lowest of the negro tribes, and contrasted most unfavorably with the sobriety of the Bongo women, who are submissive to their husbands, and yet not servile. The very scantiness of the clothing of the Monbuttoo women has no excuse. Carved benches are the ordinary seats of the men, but the women generally use a one-legged stool! While the Dinka women, leaving perfect nudity as the prerogative of their husbands, are modestly clothed with skins; while the Mittoo and Bongo women wear their girdle of foliage, and the Niam-niam women their apron of hides, the women of the Monbuttoo—where the men are more scrupulously and fully clothed than any of the nations I came across throughout my journeys—go almost entirely naked."

But, as every page and paragraph of this work is of absorbing interest, we are weary of the mental conflict as to which shall have place in our limited space. We will conclude with the following:

"I always made a rule of eating alone. A solitary European, as he proceeds farther and farther from home, may see his old associations shrink to a minimum; but, so much the more, with pertinacious conservatism, will he cling to the surviving remnants of his own superiority. Nothing can ever divest him of the thought as to how he may maintain the prerogative, which he takes for granted, that he is a being of some higher order. Many a misanthrope, in his disgust at the shady side of our modern culture, may imagine that, to a traveler, in his intercourse with the children of Nature, the thousand necessities of daily life must seem but trifles vain and empty, to be dispensed with without a sigh. Such a one may fancy that the bonds which fasten him to the world of civilization are weak, and all waiting to be rent asunder as soon as Nature is left to assert her unfettered rights; but, from experience, I can assure him that the truth is very different. With the fear of degenerating ever before his eyes, the wanderer from the realms of civilization will surely fix his gaze almost with devotion on the few objects of our Western culture that remain to him, which (however trivial they are in themselves) become to him symbols little less than sacred. Tables and chairs, knives and forks, bedding, and even pocket-handkerchiefs, will assume an importance that could never have been anticipated, and it is hardly too much to aver that they will rise to a share in his affections."

Fungi: their Nature and Uses. By M. C. Cooke and M. J. Berkeley. New York: D. Appleton & Co. "International Scientific Series," No. XV. Pp. 300. Price, $1.50.

A very interesting tract of the vegetable kingdom, which has hitherto received but little popular attention, is here reported upon by two of the most eminent English authorities upon the subject. In all that relates to those numerous and curious forms of vegetable growth called *fungi*, in their familiar forms, as seen by everybody in field and forest, and in their still more wonderful microscopic varieties, Rev. M. J. Berkeley, the venerable Rector of Sibbertoft, is perhaps the first authority in the world. Though a hard-working clergyman, he has found time to master and to extend one of the most interesting provinces of botany hitherto as obscure as it is extensive. He engaged to produce a book for the "International Series" upon this subject, but, finding, from the multiplicity of his engagements and his uncertain health, that he could not accomplish it satisfactorily, he associated with himself the next ablest man of England in this field, Dr. M. C. Cooke, who has done the principal work, which now appears under the critical editorship of Dr. Berkeley himself. Readers who desire to become acquainted with the subject-matter of this volume, and to form some general idea of its scope and importance, are referred to the opening article of the present number of the Monthly, and, if its perusal

interests them, they will find that the book gives the clearest and fullest account of the subject for common readers that has yet been published.

The following passages are from an able review of it in the London *Athenæum:*

"The present volume may be taken as a general introduction to the previous one, and is of much wider interest than it. Physiologists and botanists have come to recognize and appreciate, much more fully than heretofore, that the solution of many vexed problems in the life-history both of plants and of animals is to be sought in the investigation of the mode of life of those so-called lower organisms, fungi and algæ. Speaking in general terms, we may say that the phenomena of reproduction are at least as well, if not better, understood among these plants, once considered sexless, as among organisms of higher rank, and it seems highly probable that when observers avail themselves of the joint use of chemistry and of the microscope that the essential phenomena of nutrition will also be made clear. English students not familiar with the modern literature of Germany and France are at a great disadvantage in this matter. With the exception of Mr. Berkeley—*salve magne nomen!*—few have devoted themselves to the study of these plants, and still fewer to the study of their physiological history. It has thus chanced that what little most English botanists know of these matters, they have gained in a large degree from condensations and abstracts in scientific journals from the writings of German and French observers. Happily, there have been indications of late that English students are beginning to devote themselves to this difficult but most promising field of inquiry. The discussions on so-called spontaneous generation; the inquiry whether or no fevers and other diseases owe their origin to the introduction and multiplication of germs within the body; the disastrous consequences following the attacks of fungi on vines and on potatoes, all excited interest in the study of these organisms, and induced observers to turn their attention to them.

"From this point of view, Dr. Cooke's book is well timed. It comes at a period when the importance of the study, both from the stand-point of pure science and from that of practical utility, is becoming clearly recognized. Such an epitome of what is known as to the growth of fungi is, therefore, peculiarly welcome, the more so as no modern work of the kind exists, Mr. Berkeley's 'Introduction to Cryptogamic Botany' having been published several years ago, while its style is obscure and its arrangement not suitable to the requirements of beginners. Dr. Cooke's book contains an admirable *résumé* of what is known on the structure, growth, and reproduction of fungi, together with ample bibliographical references to original sources of information.

"One of the most interesting chapters in the volume to the general reader, who does not care to follow the author in the technical, and still somewhat obscure details of the structure and classification of these plants, is that devoted to the influences and effects of fungi. Apart from what are popularly known as poisonous fungi, it is assumed by many that certain diseases, such as cholera, various fevers, measles, diphtheria, etc., are actually caused by the introduction into the system of fungus-spores. Now, there is ample evidence to show that fungus-spores are introduced, and that in some diseases, e. g., diphtheria, fungus-moulds, the result of the development of such spores, have been found, but there is no certain evidence either that the spores or the developed plant has any thing to do with the disease. The opinion of those best qualified to judge is that the fungi are there in consequence of the disease, not the disease in consequence of the fungi. We are glad to see, with reference to this matter, that the author summarizes the important conclusions of Drs. Cunningham and Lewis—the more so as those conclusions, which are based on important observations, are contained in official publications not readily accessible to the general public. Dr. Cunningham establishes without question that the air is always charged more or less with these minute spores, but that no connection can be traced between the numbers of bacteria, spores, etc., present in the air, and the occurrence of diarrhœa, dysentery, cholera, ague, or dengue, nor between the presence or abundance of any special form or forms of cells and the prevalence of any of these diseases. On the other hand, it is a matter of dispute at the present moment whether the minute organisms called bacteria may not be developed in the body itself, and, in some cases, produce fungoid structures in the tissues, and, as a consequence, disease. Throughout the volume we find evidence of the care that has been taken to summarize the most recent information, even to the remedies proposed for the hollyhock-disease in the gardening journals of the present year."

The American Garden: a Monthly Illustrated Journal devoted to Garden Art. 24 pages. $2 a Year. Beach, Son & Co., No. 7 Barclay Street, New York.

Under the able editorial management of Mr. James Hogg, this journal is doing excellent service in the interest of gardening and fruit-culture. It contains each month a large amount of interesting and valuable matter, characterized, in the main, by a directness of statement and common-sense that quickly win the confidence of the reader, and assure him that he is in the hands of a safe and competent instructor. From the thirty-two titles in the last number, the following may be taken as a fair sample of the variety and practical character of the subjects treated: "Insects injurious to Room-Plants," "Fresh-Water Aquaria," "The Artistic Influence of Flowers," "Tropical Scenery," "About Ferns," "The Truffle," "*Stillingia Sebifera*, or Tallow-Tree," "The Carolina Poplar," "Watering Plants," and "Thinning out Fruit."

Birds of the Northwest. By Elliot Coues, M. D., U. S. A. 791 pages. Washington: Government Printing-Office, 1874.

The basis of the present volume is mainly an unpublished report prepared by the author, in 1862, upon the ornithological collections made in the Missouri region by the naturalists of the expedition under Captain Reynolds, and afterward extended so as to embrace the ornithological results of previous explorations, in 1856–'57, by Lieutenant Warren, in the region of the Upper Missouri, Yellowstone, and Platte Rivers. In 1872 Dr. Hayden, U. S. Geologist, expressed to the author his desire to publish a treatise on the ornithology of the Western Territories, which he had explored. Dr. Coues undertook the task of elaborating the material collected since the writing of his original report, and the whole result is published in the book now before us, which is believed to be fairly abreast of the present state of the science. To bring the work within the compass of a single volume, and to give it a distinctive character apart from the general work on "North American Ornithology" in preparation by Profs. Baird, Brewer, and Ridgway, its scope is restricted to the Missouri region. The birds of this region, like most others of North America, having been repeatedly and sufficiently described, text of this technical kind has been omitted as a rule, to make room for fresher matter of more general interest, but particular plumages, not yet well known, are described. The distribution of the species, their residence or migration, and their abundance or scarcity, are worked out, not only within the region indicated, but throughout the general area they inhabit. All the species at present known to inhabit this region are given, and represent a large majority of the birds of North America. The author is brief in the cases of the best known Eastern birds, in order to devote more space to the history of species upon which less has already been written. Three families, *Laridæ*, *Colymbidæ*, and *Podicipidæ*, are made the subjects of special monographs.

The Elements of Embryology. By Michael Foster, M. D., and Francis M. Balfour, M. A. London: Macmillan, 1875. 272 pages. Price, $2.25.

This is the first installment of a systematic introduction to the study of embryology. For the sake of making the first steps in this interesting branch of science as easy as possible, the authors consider in the present volume only the embryogeny of the common fowl. The development of the chick once mastered, the study of other forms becomes an easy matter. The work consists of nine chapters, with an Appendix. In Chapter I. we have a description of the egg, and an account of the changes which take place up to the beginning of incubation. Chapter II. is a summary of the history of incubation. The other chapters, down to the ninth, indicate the changes which occur from the first day of incubation down to the end of that process. Chapter IX. is on the development of the skull. In the Appendix are given practical instructions for studying the development of the chick.

Improvement of Health. By James Knight, M. D. 406 pages. Price, $1.50. New York: G. P. Putnam's Sons, 1875.

This is the second edition of this book on the improvement of health by natural means, including a history of food and a consideration of its substantial qualities.

The work opens with a statement of the various unfavorable influences that tend to the enervation of the physical powers of parents; and this is followed by an outline of man's organization, development, and proper sustenance, and by an elucidation of the relations which exist between the vegetable and animal kingdoms, whence his subsistence is obtained. The book contains few cuts, and these are poorly made.

Catechism of the Locomotive. By M. N. Forney, M. E. 600 pages, 12mo. Price, $2.80. New York: The Railroad Gazette. 1875.

The object of this book is to furnish a clear and easily-understood description of the principles, construction, and operation, of the locomotive-engine of the present day, a subject not concisely or adequately treated in any one similar book. It is intended not only as a hand-book for all classes of mechanics and railroad-men, but as a readable book of practical information for amateur engineers, students, and general readers. The headings of a few chapters taken at random are: "The Steam-Engine;" "Forces of Air and Steam;" "General Description of a Locomotive-Engine;" "Different Kinds of Locomotives;" "Accidents to Locomotives;" "Responsibility and Qualification of Locomotive Runners." The subjects presented are treated simply and plainly, in the form of question and answer, of which there are 563. The book is illustrated by 230 woodcuts and many plates.

A New Treatise on Elements of Mechanics. By John W. Nystrom, C. E. 352 pages, 8vo. Price, $4.00. Philadelphia: Porter & Coates, 822 Chestnut Street. 1875.

This new treatise on mechanics has for its object the establishment of strict precision in the meaning of dynamical terms, and the classification of physical quantities into elements and functions. It is written for students of mechanics, by a practical engineer; and the terms adopted in it are those used in the machine-shop, rejecting the ideal vocabulary heretofore used in text-books and colleges; thus the author rejects such terms as "efficiency of force," "working force," "quantity of motion," "mechanical power," "mechanical effect," "energy," etc., as having no definite meaning, or being redundant expressions meaning "force," "power," or "work." The first 56 pages treat of "Statics," and the next 221 pages are given to "Dynamics." A short chapter on the "Dynamics of Sound," a chapter on the "Mechanics of Astronomy," and an Appendix elucidating a duodenal system of arithmetic, measures, weights, and coins, complete the work, the whole of which is illustrated by 242 woodcuts.

Familiar Lectures about the Teeth. By Henry S. Chase, M. D. 68 pages, cloth. St. Louis: Gray, Baker & Co.

The contents of this neat little publication are designed particularly to enable *mothers* to understand and take care of the *growth* of children's teeth. The author first gives several illustrations with descriptions, showing the position of the teeth in the jaws, together with the usual time of appearance of the milk-set and permanent set of teeth. He then treats of the structure of the teeth, the changes they undergo, and the nutrition which they demand, the same as other parts of the body. The food must furnish bone-material as well as flesh-material. Phosphate of lime gives hardness to the teeth and bones, but it must be organized by a plant before it becomes fit food for an animal: "Artificial salts will not nourish the teeth by being taken as food; yet some persons have recommended that they be put into bread for that purpose." Other subjects are "Early Growth of the Teeth," "Infants' Teeth," "Dental Decay," "Children's Teeth," "The Six-Year Molars," "Plugging Teeth," "Effects of Medicine on the Teeth," "Diseases of the Teeth," "Extraction of Teeth," and "Artificial Teeth." The book is a good one, and will fully repay an attentive perusal.

A New Manual of Physiology. By Prof. Küss. Boston: James Campbell, 1875. 531 pp., 12mo. Price, $2.50.

The contents of this volume are a course of lectures on physiology, delivered by Prof. Küss, at the Medical School of the University of Strasbourg; edited by Mathias Duval, M. D., of the Medical Faculty of Paris; and translated by Robert Amory, M. D., formerly Professor of Physiology at

the Medical School of Maine. The object of the work, as stated in the preface, is to supply the want of an English text-book in which the functions of living tissue are closely compared and combined with its texture; or, in other words, a book wherein the relations of physiology to histology are carefully presented; for, while there are many good works on physiology, to which the student can refer for a knowledge of the subject, a concise treatise, within the limits of the means of medical students, has been a want hitherto supplied only by treatises in French or German. The book is embellished with 150 woodcut illustrations.

Report of the Commissioners of Lunacy to the Commonwealth of Massachusetts. Boston, January, 1875.

This pamphlet of 76 pages contains the separate Reports of the Commissioners, Nathan Allen and Wendell Phillips, to which is added, in an appendix, a letter to the Commissioners by S. E. Sewall. The Report gives the number of insane in the State as, approximately, 3,624, but the Commissioners are persuaded that, if more thorough measures were taken for ascertaining the number, they would exceed *four thousand.*

We observe with pleasure the addition of four pages to the *Engineering and Mining Journal*, edited by Richard P. Rothwell, C. E., M. E., and Rossiter W. Raymond, Ph. D. Heretofore its weekly issue consisted of sixteen pages, now it is twenty. But, besides enlarging, the publishers announce their intention of otherwise adding to the value of the journal. Thus they will make more liberal use of engravings to illustrate subjects of professional interest, and questions of practical importance in mining, metallurgy, and gas-engineering, will receive special attention. Another new departure, something in the nature of *Notes and Queries*, is announced, and cannot fail to enhance the value of the paper. It is the publishers' desire to have their pages used as a " " medium for asking and giving information on subjects connected with mining and metallurgy, or general science." Subscription, $4.00. Publication-office, 27 Park Place, New York.

International Scientific Series.—If the last volume of this series, on "Fungi," be thought somewhat remote from the urgent solicitudes of the American mind, no such objection can be urged against the contribution of Prof. Jevons to this series, now in press, entitled "Money and the Science of Exchange." Prof. Jevons is not only a logician of originality and eminence, and author of a recent profound work on the "Principles of Science," but he is a professional student of political economy, and the author of important works upon this subject also. He brings a disciplined mind and a comprehensive knowledge of the subject to the discussion of that important branch of economical science which deals with currency, and may be expected to give in his new volume a clear and compact statement of the subject, as far as its scientific principles have been worked out. Such a volume cannot fail to be useful in this country, where the interest in money is so intense as to be surpassed only by the general ignorance of its nature, offices, and laws.

"The Unseen Universe."—Under this title an anonymous work will be shortly issued from the press of Macmillan, treating of the religious bearings of the most advanced science, in such a way as to arouse the interest of both scientific and religious thinkers. Since its announcement the work has been anxiously looked for, and there is much speculation as to its authorship.

## PUBLICATIONS RECEIVED.

The Religion of Humanity. By O. B. Frothingham. Pp. 338. New York: Putnam's Sons. Price, $1.50.

Home Sketches in France. By Mrs. Henry M. Field. Pp. 256. New York: Putnam's Sons. Price, $1.50.

Fifth Catalogue of Seventy-one Double Stars. By S. W. Burnham, Esq. Duplicity of the Principal Star of New Scorpii (same author). Reprint from Royal Astronomical Society notices.

Iron and Steel. By Adolf Schmidt, Ph. D. Pp. 12. St. Louis *Times* print.

History of Greece. By C. A. Fyffe (His-

tory Primers). Pp. 127. New York: Macmillan. Price, 40 cents.

Pneumo-thorax. By Austin Flint, Sen., M. D. (series of American Clinical Lectures). Pp. 18. New York: Putnam's Sons. Price, 40 cents.

Spectroscopic Examination of Gases from Meteoric Iron. By Arthur W. Wright. Pp. 8.

The Past and Future of Geology. By Joseph Prestwich, M. A., F. R. S. London: Macmillan. Pp. 50. Price, two shillings.

Possibility and Probability of Supernatural Revelation. By Rev. Horace Bumstead. Pp. 15. Minneapolis: Johnson & Smith.

Doubt. By J. N. Stiles. Pp. 19. Chicago: Beach, Barnard & Co.

Philadelphia School of Anatomy. By William W. Keen, M. D. Pp. 32. Philadelphia: Lippincott.

Skew Arches. By E. W. Hyde, C. E. Pp. 104. New York: Van Nostrand. Price, 50 cents.

The Iron-clad Ships of the World. By M. P. Dislere. Pp. 29. Washington: Government Printing-Office.

The Centennial of Chemistry. Pp. 208. Philadelphia: Collins, Printer. Price, $1.00.

Cretaceous Lamellibranchs, collected at Pernambuco. By Richard Rathbun. Pp. 15.

Journey in Honduras. By R. C. Huston, C. E. Pp. 39. Cincinnati: R. Clarke & Co. Price, 50 cents.

Catalogue of American Grape-vines. Bush & Son, Bushberg, Jefferson County, Mo.

Transits of Venus (Proctor). New York: Worthington.

Manual of Diet in Health and Disease (Chambers). Philadelphia: Henry C. Lea.

Navigation, in Theory and Practice (Evers). Putnam's Sons.

Theology of the Coming Man. By G. Eppley, M. D. Pp. 11. Lewisberry, York County, Pa. The Author.

Vertebrata of the Eocene of New Mexico (Cope).

Theory of Solubility (Walz). Philadelphia: Collins, printer.

Causes of Irregularity in Development of the Teeth (Kingsley).

Munroe's Philosophy of Cure.

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## MISCELLANY.

**Disastrous Balloon Ascent.**—On the 18th of April the balloon Zenith made an ascension from Paris, carrying three aëronauts, Messrs. Gaston Tissandier, Sivel, and Crocé-Spinelli. All three were aëronauts of long experience, and qualified in every way for making accurate scientific observations on the meteorological phenomena of the upper strata of the atmosphere. They carried with them a full set of such philosophical instruments as would be of service in ascertaining elevations, constitution of the atmosphere, temperatures, and the like. They carried also a supply of pure oxygen, for use when the air should be found too rare to support respiration. Having risen to the height of 7,000 metres (22,960 feet), Tissandier observed that his companions looked pale; he himself felt weak, but refreshed himself by inhaling a little of the oxygen. Sivel soon after threw out ballast, and the balloon commenced to ascend rapidly. All at once Tissandier was so feeble that he could not even turn his head; he tried to seize the oxygen tube, but was unable; his mind still lucid. Looking at the barometer he saw that it indicated an elevation of 8,000 metres (26,240 feet), but he had not the strength to call the attention of the others to the fact. He soon after fell into a sort of swoon, but twenty minutes later revived for a moment, finding the balloon descending rapidly. Sivel and Crocé were now lying at the bottom of the car insensible. Again he sank fainting, and a few minutes later found himself shaken by the arms, and, looking up, recognized Crocé, who told him to throw out ballast, for the balloon was descending at a very rapid rate.

Crocé now unfastened the aspirator and threw it out, as also some ballast, extra wraps, and the like. This caused the balloon again to ascend, and Tissandier relapsed once more into insensibility. On recovering consciousness, he found the car rushing

downward with frightful velocity. He tried to arouse Sivel and Crocé, but they were immovable; Sivel's face was black, his eyes dull, mouth wide open and full of blood. Crocé's eyes were closed, and his mouth blood-stained also. Having come down to the earth, Tissandier dropped the grapnel, but it failed to hold firmly, and the car was dragged across the fields by a violent wind. He succeeded, however, in grasping the cord of the valve, and the balloon was soon emptied. Crocé-Spinelli and Sivel were dead. Tissandier was in a high fever, but he was kindly cared for by the inhabitants of the village of Ceron, in the vicinity of which he landed, after having been in the air over three hours.

The disaster attending this memorable ascent has delayed the publication of the scientific results of the voyage. These, however, are understood to be of high importance, and we will present them to our readers at an early day. The greatest altitude observed by M. Tissandier was not very remarkable, when compared with Glaisher and Coxwell's highest in 1862. These aëronauts reached the enormous altitude of 37,000 feet, which is more than 10,000 feet in excess of Tissandier's 8,000 metres. But, while Tissandier lay insensible, the Zenith may have attained still greater elevations; this question will be decided by the records of the self-registering barometers, which were sent to the French Academy under seal.

**Cave Explorations.**—A number of caves containing the remains of animals were recently discovered in Worcestershire, England, on the banks of the river Wye. At a meeting of the county Scientific Society the president described a visit made by him to these caves, in company with Dr. Carpenter. Three of the caves only were visited. In one were found three human skulls, with coins and ornaments belonging to the Roman period. The soil in which these objects were buried having been removed, the explorers found a layer of solid stone, so thick and hard that it had to be blasted with gunpowder. Under this layer were found bones belonging to a single animal—*Ursus spelæus.* Another layer of stone was then likewise removed by blasting, and the explorers found fossil bones of sundry extinct species, viz., the remains of a mammoth, in a state of wonderful preservation; all the bones of a rhinoceros; the *débris* of cave-lions, cave-bears, and also of several hyenas. The Worcestershire Scientific Society intends to acquire possession of one of the caves.

**Origin and Distribution of Ammonia in the Air.**—In a communication to the French Academy of Sciences, Schlösing states as follows the results of his researches on the origin of the ammonia diffused on the surface of the soil, its circulation, its variations in the atmosphere, and its distribution between the sea, the continents, and the air. It is a well-known fact that, in the course of the transformations of organic matter, a certain amount of nitrogen is set free; also that this gaseous nitrogen is not assimilable by organisms. Hence the necessity of some agency which shall take this free nitrogen and cause it to reënter into combination. The author, after criticising the various opinions put forth on this subject, assents to the theory of Boussingault, who holds that, under the influence of atmospheric electricity, nitric acid is produced in the air. Further, he says that the surface of the continents is essentially an oxidizing medium; that nitrification is there abundantly developed; and that a portion of the nitrates thus formed enters again into the cycle of life, while the rest is carried into the sea. Experience also shows that if the decomposition of organisms produces nitre on the continents, it produces ammonia in a medium so little oxidized as is the sea. Hence the author recognizes on the surface of the globe a regular circulation of nitric acid and of ammonia, taking place in this way, viz., nitrous production in the air, nitrous gains from the air to the continents, transfer of nitrates to the sea, formation of ammonia in the saline medium; finally, disengagement and passage of the alkali into the air, to be given back again to the continents.

**Mortuary Statistics of Virginian Cities.**—The following mortuary statistics, taken from the official reports of three Virginian cities, would seem to show that the African race is declining in the Southern States:

The total white population of Richmond is given as 33,452, and the deaths for January 25 males and 16 females. The colored population of the same city is given at 27,213, and the deaths as 40 males and 36 females. Norfolk had, for the same month, in a white population of 12,000, 3 male deaths and 5 female, while its colored population of 8,000 gave 6 male and 7 female deaths. The white population of Lynchburg is 6,500, and the colored population the same. Among the whites there were 4 males died and 1 female, while among the colored people 8 males died and 10 females. In Richmond, the number of still-born infants in the white population was 5, in the colored 11; in Lynchburg the number was 3 and 7 respectively. In Norfolk the number was even.

**Temperature of the Body in Disease.**—The normal surface temperature of the human body, in temperate climates, is about 98.°5, any persistent variation from this, whether by depression or by elevation, indicating disease. In the tropics, the normal temperature is one degree higher. Hitherto it has been supposed that, when in fevers the temperature rises over 108°, recovery is impossible, unless a reduction is effected by the cold bath. The *Lancet* gives an instance of recovery where the thermometer indicated a temperature of over 122° in the armpit of a patient suffering from injury to the spine. The history of this extraordinary case is as follows: On September 5, 1874, a young lady met with an accident in the hunting-field, whereby two ribs were fractured; at the same time she complained of pain in the back. A surgeon, Mr. J. W. Teale, was soon in attendance. A few days after the accident the temperature was 101°, but, in the space of a fortnight, it became normal. The fractured ribs united, but pain and tenderness still existed over the sixth dorsal spine. On October 3d the temperature rose to 100°, and then to 101°; and it still continued to rise in spite of the application of ice-bags to the spine, till, on November 6th, it was 106°. After many fluctuations, the temperature, on the 13th of November, reached the astonishing height of 122°, the index of the thermometer becoming buried in the bulb at the top of the instrument, which registered only up to 122°. During that day there was a fall of 8°, but, in the evening, 122° was again reached.

As a general rule, an increase of 1° above the normal temperature is attended with an increase of ten beats of the pulse per minute. In the present case, the pulse appears to have been the same (120) at 122° as at 108°. The normal temperature was not reached till January 10th, and, during the space of seven weeks, it never fell below 108°. We must add here that every precaution was taken against error in the indications of the thermometer. No fewer than seven different instruments, made by Harvey & Reynolds, were used, of which four had received certificates of correctness at Kew. Further, they were inspected by two or three trustworthy witnesses before and after each application, and the results were always immediately recorded in writing. Sometimes, when the thermometrical readings were highest, the hands, feet, and forehead, were icy cold, and the patient felt as if "her blood was on fire."

**"Cotton Gunpowder."**—This is the name given to a preparation of gun-cotton which, by the use of certain chemicals, is rendered perfectly safe for storage or carriage, though possessing enormous explosive power. The following account of some experiments made with cotton gunpowder we take from the *Journal of the Society of Arts*: "Cartridges were held in the hand, lit with fuses, and burned with a steady blaze, while, when ignited by detonators, they exploded with a loud report. Ten pounds of the substance was placed on an anvil, and an iron pile-driver weighing one-half ton was allowed to fall 15 feet upon it, without causing an explosion. Two barrels, each containing 40 pounds, were placed in a pile of fagots. Upon these being fired, the powder burned with a steady but intense flame, and without any tendency to explosion. A solid block of steel, about one-half ton in weight, was bored to the depth of 6 inches, and a 6-ounce cartridge was inserted in the hole. It was split into two pieces. But the greatest exhibition of force was made in two experiments with

steel ingots. In the first experiment, 4 ingots of 8 inches square and 3 feet long were used. In the centre of these four masses of steel as laid together, two pound cartridges of the powder were placed, and kept in their place with a few handfuls of clay. In the second experiment the four ingots were each 11 inches square, and the charge used $2\frac{1}{2}$ pounds. The 8 ingots were all broken in halves; some of these massive pieces of steel were sent flying high in the air, falling 30, 35, and, in one case, 45 yards away. At the close of the experiment, a torpedo of 50 pounds of this powder, sunk 10 feet in the river Swale, but not resting on the bottom, was fired. An immense body of water was projected high in the air, and any vessel which might at the time have been passing over it would have suffered severely."

**A Thorough State Survey.**—Prof. N. S. Shaler publishes in the *Atlantic Monthly* an article on a survey of Massachusetts, advocating a more minute reconnoissance of the topography, geology, zoölogy, botany, agricultural resources, climate, etc., of that Commonwealth, than has hitherto been attempted with respect to any portion of the territory of the United States. In this great enterprise, the first thing to be done is, to secure the best map. Massachusetts has the good fortune to have her shore-belt map completely made by the Coast Survey. Cape Ann and Cape Cod, and the bordering islands, constituting about a tenth of the total area of the State, have all been done on a scale of $\frac{1}{10000}$, or about six inches to the mile of distance. The entire State, on the same scale, would be represented in a record-map about 90 by 54 feet. "On this plan," says Prof. Shaler, "the surveying and improvement of private grounds could always be accomplished, tax-levies made, and, in short, our civilization could be organized upon it." In this way the topographical portion of the survey would probably cost not over $750,000, a sum which Massachusetts could easily afford.

In the geological survey, every stratigraphical question, every question in chemical geology, should be followed to its utmost point. Some of the problems which would arise are economical, have money in them; the others are economical too, in that higher sense which finds all truth profitable. The problems of direct economical interest are: distribution of water, its storage and quality; building-stones; deposits of coal; distribution of metals; reclamation of marshes; retimbering of the exposed parts of the coast, etc. As for purely scientific problems, probably no other known fossils have so much value for the science of to-day as those wonderful footprints of the Connecticut Valley.

A large part of the necessary work for the complete description of Massachusetts animals and plants is already done, and only needs to be brought together and classified. The State already has nearly $1,000,000 invested in the Museum of Comparative Zoölogy, and, in the work of cataloguing the animals, this noble institution can make a substantial return through the students it has trained and the collections it has made. With good maps and good catalogues of the natural productions of a country, the teaching of natural science becomes possible to a degree that cannot be hoped for under other circumstances.

**The Microscope as a Detective.**—The microscope, as an agent in the detection of crime, has been alternately commended and condemned. It was recently employed in a Connecticut court of justice to discover, in the clothing of a man charged with murder, minute filaments from the shawl of his alleged victim. Dr. J. G. Richardson lately read before the Philadelphia Academy of Natural Sciences a paper on the "Value of High Powers in the Diagnosis of Blood-Stains," in which he shows that the red blood-globules of various domestic animals, as the ox, cat, pig, horse, sheep, goat, are all so much smaller than the human red disk, that we can positively distinguish stains produced by human blood from those caused by the blood of any of these animals. To furnish positive demonstration of the facts of the case, Dr. Richardson obtained six specimens of blood-clot, from the veins of a man, an ox, and a sheep, selected without his knowledge, and so marked as to furnish no clew as to which animal they were derived from. By the microscopical characters alone he was able to determine with perfect correct-

ness the origin of every one of the samples. The corpuscles of the human blood averaged $\frac{1}{3430}$ inch diameter, those of the ox-blood $\frac{1}{4874}$, and the sheep's blood $\frac{1}{5952}$.

**The Cincinnati Zoological Garden.**—We are indebted to Mr. G. H. Knight, of Cincinnati, for an account of the Zoölogical and Botanical Garden about to be established in the northern suburbs of that city. The projected garden is to be, as far as possible, a complete representation of the fauna and flora of this continent. Efforts will be made to render the ground a complete *arboretum*, in which each tree and shrub will be plainly labeled according to the scientific classification, with the common name appended. Fresh and salt-water aquariums, on a large scale, will add to the popular attractions as well as to the scientific value of the establishment. Nor will the collection be restricted to a representation of the animal and vegetable worlds; there is also to be a novel geological feature added, viz., an artificial section of the earth's crust, made up of the actual component rocks in their natural positions, accompanied, possibly, by some of their paleontological characteristics; that is to say, their extinct fauna and flora restored. The tract of land secured for this garden is, for the most part, an elevated plateau of about sixty-seven acres, very central and accessible in location. The Cincinnati Zoölogical Society, to whom all the credit of this great enterprise is due, have already in hand over $100,000 for the beautification of the grounds and the construction of the necessary buildings, laying out of paths, etc. A naturalist, who brings a large practical experience in the care of wild animals, and a landscape-gardener, who has been engaged in similar works elsewhere, have been engaged, and are already busily at work examining the ground and making necessary preparations.

**The Dietetic Value of Gelatine.**—The theory that gelatine passes through the system undigested, and thus contributes nothing toward the nourishment of its tissues, has recently been subjected to a reexamination by Etzinger, with results that appear to contradict the current view. By submitting fine gelatine, and also the various gelatine-yielding tissues, such as bones, cartilages, tendons, connective tissue, etc., to the action of artificial gastric juice, he shows, in accordance with Boerhaave and others, that gelatine is digestible, breaking up and becoming dissolved more or less rapidly, according to the form in which it is presented to the solvent. Being satisfied on this point, the next question was, "Is the gelatine, after solution or digestion, of any service in nutrition?" To determine this, a careful dieting of animals was instituted, with coincident analysis of their urine and fæces. The results showed that, in the cases of bone, cartilage, and tendons alike, these substances not only undergo digestion, but are absorbed into the blood, and play an important part in nutrition. Instead, therefore, of being entirely cast aside as useless articles, they may be consumed in moderate quantities with decided advantage.

**The Origin and Structure of Fulgurites.**—Mr. Frank Buckland publishes, in *Land and Water*, an account written by his father, the late Prof. Buckland, of certain vitreous tubes discovered in sand-hills, near Drigg, in Cumberland. Three of these tubes were found on a single hillock about thirty feet above the level of the sea, the diameter of each being about an inch and a half. An excavation having been made about one of them, it was found to descend perpendicularly through the sand about thirty feet. At about twenty-nine feet, the sand was succeeded by a bed of pebbles. Here the tube came in contact with a piece of hornstone porphyry, from which it glanced off at an angle and then resumed its vertical position. Below this point the tube, becoming extremely delicate, was frequently broken, and at the distance of a foot the sand fell in, preventing further investigation. The tube appears to have tapered in its descent, its diameter at the bottom of the excavation being only half an inch. Small lateral branches proceeded from different parts of the stem, not over two or three inches in length, nor one-quarter inch in diameter at the points of insertion. They were conical, the points being turned downward. The outside of the tube is coated with an agglutinated sand, which, viewed with a lens, is seen to consist of black and opaque

white grains mixed together and rounded as if by instant fusion. The wall of the tube is about one-twentieth of an inch thick, and very solid and rigid. In the opinion of Prof. Buckland, lightning is the only agent that could at once supply the heat and force necessary to make these tubes.

A similar tube, coming from North Carolina, has been described by Prof. Leeds, of the Stevens Institute. In this case the lightning had penetrated a bed of pure white sand, melting the silex, and forming a hollow shaft two or three inches in diameter and four feet long, filled within and surrounded without by the pure white sand of the locality. The shaft, however, was discolored by finely-divided metallic iron (which does not exist in Nature at the earth's surface), and the explanation seems to be that at the immensely high temperature at which silica melts, iron dissociates from oxygen, and that here, dissociation having occurred, the metallic iron, transported by the electric flux from some subterranean depth, became incased in molten sand, and was preserved unoxidized in the vitreous tube.

**The Weakness of a Great Man.**—The vanity of the great botanist Linnæus was extraordinary, as witness the following document written by his own hand, and entitled "The Good Fortune, Services, and Fame of Linnæus:" "God gave him to wife the woman he most loved, and who cared for the household while he studied. God granted him the largest herbarium in the world, and this is his delight. God honored him with a title (chief physician), orders (knighthood), coat-of-arms (nobility), and a name among the learned. God saved him from a conflagration. No man before him ever pursued his special study with greater zeal, or had more listeners. No man before him was ever more famous throughout the whole world." The same trait of character is seen in "Flora's Body Guard," as Linnæus, curiously enough, called the most eminent botanists of his day: "General, Karl von Linnæus; major-general, Bernard Jussieu; colonels, Albrecht von Hall and J. F. Gronovius; lieutenant-colonels, Burmann, Gleditsch, Ludwig, etc.; major, J. G. Gmelin;" and so on. A lady having once visited Linnæus's cabinet, the great man made a profound impression on her by giving her some interesting information about each specimen. At last she exclaimed, "I can now understand why Linnæus is so famous in the whole province of Upsala." But Linnæus, who had expected to hear "all over the world," instead of "in the province of Upsala," was hurt by the meagreness of the lady's adulation, and dismissed her curtly enough. In order to sound the depths of the great botanist's vanity, an acquaintance once saluted him as the Sun of Botanists, the Jupiter of Scholars, Nature's Secretary, an Ocean of Knowledge, a Traveling Mountain of Erudition, and the like. Far from being displeased at such fulsome flattery, Linnæus interrupted the panegyrist at the close of each phrase, embraced him, and again and again called him his best and dearest friend.

**Perception of Color by Bees.**—To test the faculty possessed by bees of distinguishing between colors, Sir John Lubbock brought a bee to some honey, which he placed on blue paper, and about three feet off he placed a similar quantity of honey on orange paper. After the bee had returned twice he transposed the papers, but the bee returned to the honey on the blue paper. After she had made three more visits, always to the blue paper, he transposed them again, and she again followed the color, though the honey was left in the same place. The papers having been again transposed, the bee returned to the former site of the blue; but, when just about to alight, she noticed the change of color, and without a moment's hesitation dashed off to the blue. No one, says he, who saw her at that moment, could have entertained the slightest doubt of her perceiving the difference between the two colors.

**Poisoning with Extract of Hemlock.**—The following is a condensed history of the remarkable case of Frederick W. Walker, who died in Brooklyn, on the 3d of April, from an overdose of extract of hemlock, taken with the hope of controlling the symptoms of an annoying and obstinate complaint. The rare force of will and coolheadedness displayed by the patient in noting and detailing the effects of the drug up

to almost the last moment of his life, recall the celebrated case of Amédée Berthollet, who, while dying of suffocation by charcoal-gas, kept a record of his sensations as long as he was able to hold the pen.

Some time before his death, Mr. Walker had been struck in the temple by a truck-pole, the result of which injury was blepharo-facial paralysis, or spasms of the facial muscles and the eyelids. These symptoms were extremely troublesome in themselves, the spasms often continuing for hours at a time; but scarcely less annoying was the fact that the contortions came on without premonition, and thus the patient often had the misfortune to excite the derision of others by the hideous grimaces which he could not control. The best medical advice had been resorted to without avail. Brown-Séquard performed many severe operations on the patient, such as actual cautery and severing of the facial nerves; the surgeon even cut out considerable portions of nerve-fibre in the attempt to control the spasms. Brown-Séquard having returned to Europe, Mr. Walker came to Prof. C. R. Agnew for treatment. Dr. Agnew tried to relieve the spasm of the right eyelid by dividing the muscle which surrounds the corner of the eye; but the operation failed. On Saturday, April 3d, Mr. Walker visited, by appointment, Dr. Agnew's office, for the purpose of being treated with the extract of *Conium maculatum*, or hemlock. The drug was administered by Dr. Webster, Prof. Agnew's associate; the first dose, forty drops, being taken at 10.25 A. M. At 10.50 the dose was repeated, as also at 11.15, and half an hour later sixty drops more were given. No effect was observable. The patient was then directed to obtain from Dr. Squibb, of Brooklyn, an ounce of his fluid-extract of conium, and to follow minutely that physician's directions as to its administration. Both by Dr. Webster and by Dr. Squibb Mr. Walker was again and again charged to stop taking the conium the moment he "felt any effect of the drug, *such as muscular relaxation, or vertigo*." The dose recommended by Dr. Squibb was fifty drops, to be repeated in half an hour, in case the symptoms did not present themselves. From the record taken down from the patient's own lips, it is clear that the admonitions of the doctors were disregarded. We give the record, to show the stoical calmness of the man, while the shadow of death was gathering upon him:

"4.10 P. M., took fifty minims Squibb's fluid-extract of conium (hemlock); 4.40 P. M., effect very decided in dizziness, relaxation of muscles and limbs; fifty minims more then taken; difficulty of walking immediately and want of power to control movements; forced to lie down, but no mitigation of spasms, limbs and legs weak, unable to hold up head, speech thickening some, pain and heaviness in top and back part of head; pulse fifty-six.

"5.15 P. M., took fifty drops; some nausea, some tremor at base of clavicle and in muscles across the chest, just above the sternum; no diminution of spasms about eyes nor of photophobia.

"5.25 P. M., drowsiness; inclined to sleep.

"5.40 P. M., eyes difficult to open, speech difficult, fullness in throat, prostration nearly complete, diplopia (double sight) vastly increased.

"6.10 P. M., nausea, twitchings on right side, unable to articulate, eyes closed, fullness almost to suffocation in throat, pulse about sixty. At eight in part—" He never spoke again.

**A New Respirator.**—A respirator, intended for the use of miners, firemen, and others, whose duties so often expose them to danger by the inhalation of deleterious gases, was recently tested at the Barclay & Perkins Brewery, London. The apparatus is the invention of a Frenchman, Denayrouze. It consists of a tube about an inch in diameter internally, made of flexible spiral wire and India-rubber, and so strong and well protected as to bear the weight of a heavy man without collapsing. The tube is attached to a belt which is firmly buckled to the waist of the operator. The mouth-piece is very ingeniously contrived for holding in the mouth with extreme tenacity and the minimum of inconvenience. There is a glazed eye-protector, which also closes the nostrils. Inspirations are taken through the tube, and the respired air is discharged through a valve half-way between the belt and the mouth-piece. By drawing a long

breath through the tube and removing the mouth-piece a simple sentence can be loudly spoken, care being taken not to inhale without first restoring the mouth-piece. The tube is of sufficient length to communicate by one end with the outer air. A newly-emptied vat, of 1,000 barrels capacity, was selected for the scene of the experiment. Lighted candles, dipped one-eighth of an inch into the vat, were instantly extinguished without a flicker, thus showing that the air within was utterly irrespirable. The London agent of the patent, Mr. Applegarth, having put on the belt, and adjusted the mouth-piece and the eye-preservers, descended into the vat by a ladder, and, having reached the bottom, carried on a conversation with those outside, the tube serving as a speaking-trumpet.

**Robert Hardwicke.**—We have to record the death of Mr. Robert Hardwicke, the respected publisher, of London, which occurred on the 8th of March last, resulting from a stroke of paralysis with which he was seized a few weeks previously.

Mr. Hardwicke was well known by the number of useful hand-books on general science and natural history published by him at his house in Piccadilly; most of these works were beautifully illustrated, and sold at very moderate prices. But Mr. Hardwicke will be best remembered by his desire to popularize science. In this field he was an earnest and indefatigable worker, not from a wish to raise an army of pseudo-philosophers, but with the truest intention of elevating the standard of mental culture among all classes, and preparing the masses to follow and appreciate the work of those great minds who devote their lives to science.

In 1862 he started the *Popular Science Review*, a quarterly journal, and in 1865 issued *Science Gossip*, a charming little monthly, well illustrated, and sold for so small a sum as 4*d*. In 1869, under the heading of the *Monthly Microscopical Journal*, he undertook to publish the "Transactions of the Royal Microscopical Society," in conjunction with matter bearing on the same subject.

These ventures were highly creditable to the spirit and enterprise of Mr. Hardwicke, but were not so profitable as they deserved to be; they were, however, a success, and were continued up to the time of his death.

What Charles Knight was to general literature, Robert Hardwicke was to science. It was the aim of both to circulate in the homes of the people pure and readable matter, light and interesting, but worthy the perusal of reasoning beings. With Hardwicke, his work was a labor of love, for he thought that "the high prerogative of every advocate of scientific truth was not to plume himself upon his own successes, but to employ them for the good of others."

**Carnivorous Plants.**—The list of known carnivorous plants has been very considerably enlarged during the past year or two, many interesting additions having been made by sundry observers. To Mrs. Mary Treat is due the credit of having materially increased the fund of scientific knowledge with regard to this description of plants. We have already mentioned her observations on sundew, and now we have to recount her very full researches on the bladder-wort (*Utricularia clandestina*), a plant common in shallow ponds and swamps. This plant owes its vulgar name to the fact that its stem has attached to it numerous little *bladders*, the use of which has been supposed to be to float the plant. But they serve a different purpose. In December, 1874 the author placed some of these bladders under the microscope, and noticed a number of animalcules within. This discovery led to further researches during the following October. It was then found that the bladder consists of irregular cells, with clusters of star-like points (the office of which is still unknown), arranged very regularly over the inner surface. The animal most commonly seen entrapped in the bladder was a snake-like larva; but for a while the author was baffled in her efforts at finding out how the prey is taken. Soon, however, this difficulty was overcome, and the patience of the author was amply rewarded by a view of sundry animals entering into the maw of the utricularia.

One end of each bladder resembles a tunnel-net, open at the larger end and closed at the smaller. The animalcules

would sometimes dally about the entrance for a while, but eventually would venture in and push open the closed end of the net; this then closed, and the animalcule was a prisoner. In this way various minute animals—water-bear, daphnia, cyclops, cypris—were seen to enter the chamber of death. No sooner was the victim within, than it manifested alarm, drew in its feet and antennæ, and closed its shell. After death the shell unclosed again, displaying the feet and antennæ. Not one was ever seen to escape. But, now, how was the observer to know that these animals became the food of the plant? This question occupied the author for several days. If it could be proved that the contents of the bladders were carried directly into the circulation of the plant, the problem was solved. The cells were, in many instances, of a red color, and in all such cases it was observed that the stem at the point where the bladder grew was of the same color. It thus looks "as if a red fluid was carried from the bladders into the main stem, which is not specifically the fact, so far as the observations yet made determine, though the main point, that the contents of the bladders are carried into the circulation, does not seem open to question."

**Darwinism by Descent.**—Mr. Darwin, many people know, has an hereditary claim to the apostolate of the doctrine of evolution; but Dr. Erasmus Darwin's poems have long ceased to be read by the multitude, and it is not so well known how closely his philosophical creed tallies with that of his accomplished grandson. As an example, however, we take the following passage from "The Economy of Vegetation:"

"Organic life beneath the shoreless waves
Was born and nursed in Ocean's pearly caves.
First forms minute, unseen by spheric glass,
Move on the mud or pierce the watery mass;
These, as successive generations bloom,
New powers acquire, and larger limbs assume,
Whence countless groups of vegetation spring,
And breathing realms of fin, and feet, and wing."

In a note combating the "prejudices" against the doctrine of spontaneous vital production, Dr. Darwin holds that "there is more dignity in our idea of the Supreme Author of all things, when we conceive him to be the cause of causes, than the cause simply of the events which we see;" and further on intimates the unlikelihood of the larger and more complicated animals being thus produced, as they "have acquired their present perfection by successive generations during an uncounted series of ages."—*Iron.*

**Antiseptics and Infusorial Life.**—M. Parmille points out that, according to the investigations of Calvert and others, charcoal, lime, and permanganate of potash, contrary to the received opinion, facilitate rather than hinder putrefactive changes, and actually favor the formation of animalcules. Charcoal, when employed for the purification of water, undoubtedly absorbs offensive gases, and removes dissolved flavoring and coloring matters. But upon living animalcules and their germs it has no destructive effect—if any thing, rather promoting their development. Water containing a known amount of "albuminoid ammonia," when experimentally filtered over animal charcoal, has been found, on analysis, worse than before. M. Danaim found that treatment with charcoal increased the poisonous qualities of putrid blood; the explanation offered being that absorption of the gases dissolved in the liquid removed an obstacle to the development of the infusoria. Permanganate of potash is likewise without effect on living organisms, although it rapidly destroys the dead organic matter. The author considers carbolic, or, better still, cresylic acid, as the only agent which extirpates these animalcules.

**Tenacity of Life in the Wheel Animalcule.**—It has been asserted that the wheel animalcule (*Rotifer vulgaris*) may be restored to life by the application of moisture, after having been dried up, and to all appearance dead. This subject has been investigated by Prof. Leidy, and his results show that there is a very definite limit to the tenacity of life in these minute animals. Two glass slides, containing, beneath cover-glasses, some dirt, exhibited each about twelve living rotifers. After exposure to the sun's rays, the temperature being 80°, for half an hour, the moisture on the slide was dried up. The next morning water was ap-

plied, and soon the microscope showed some of the rotifers to have revived, while others remained motionless. The same slides were again submitted to drying, the cover-glass of one having been removed. Several hours after moistening them, the next day, only two rotifers were seen to be alive on each slide. Again some twenty active rotifers were exposed to the hot sun during the afternoon. These could not be revived the following morning. From all this it would appear that rotifers become inactive in comparatively dry positions, and may be revived by supplying moisture; but, when their own substance is actually dried up, it is impossible to revive them.

**Influence of Ammonia on the Color of Flowers.**—Exposure to the smoke of a cigar changes violet-colored flowers to green. This change is due to the ammonia present in tobacco-smoke. The general question of the influence of ammonia on the colors of flowers has been lately investigated by Gabba, an Italian, his method being to put a little ammoniacal solution in a basin, and place a receiver over it containing the flower. In this way blue, violet, and purple flowers were changed to green, carmine-red flowers to black, white to yellow, etc. The most singular changes were presented by flowers in which several tints are combined; the red lines changed to green, the white to yellow, and so on. After the flowers have undergone these changes, if they are placed in pure water, they retain their new coloration several hours, and then gradually resume their original hues. Gabba has further observed that the flowers of aster, which are naturally inodorous, acquire an agreeable aromatic odor under the influence of ammonia. When moistened with dilute nitric acid they change from violet to red. If inclosed in a wooden case, and exposed to hydrochloric-acid vapor, they in six hours assume a beautiful carmine red.

**Metal Roofs as Lightning-Conductors.**—In a communication to the French Academy of Sciences, E. Nouel gives the results of his observations, made at Vendôme during a very violent storm. The lightning on that occasion struck some telegraph-posts and three houses. In the case of the houses, Nouel found that the lightning followed the sheet-zinc roofing (without damage) to the spouts, and thence to the earth. The author remarks that static electricity flows always to the surface of bodies, so that a gutter and its pipe, notwithstanding the thinness of the metal, constitute an excellent electric conductor, having less resistance than the best lightning-rods; that the thunder-bolt, as a rule, falls only during heavy showers, by taking advantage of the semi-communication with the earth offered by the vertical series of rain-drops. The summary of his conclusions is as follows: 1. It is possible, almost without expense, to protect ordinary houses from lightning casualties by establishing good metallic communication between the chimney-flues and roof, through the gutters, and by trusting to the rain to complete the communication to the ground. 2. That, even for complete lightning-conductors, we should utilize as a conductor the gutters and their pipings. 3. That there is need in every case to wholly replace the conductors of lightning-rods with hollow pipes of the same mass and of greater diameter. He decidedly rejects metallic cords, because electricity, always following the conductor's surface, only selects or uses from this cord a small number of its wires, which may be easily fused.

**A Botanic Garden for Chicago.**—The Commissioners of the South Park, Chicago, have in contemplation the establishment of a Botanic Garden on the following liberal plan: First, there will be a botanic garden proper, in which all indigenous plants of the United States, and hardy species from other countries, will be arranged, as far as possible, according to their natural affinities, while hot-houses and green-houses will be provided for the reception and display of tropical plants. There will also be an arboretum, or collection of hardy trees, from all parts of the world, planted in such order as to serve the purposes of science and ornament; a garden devoted to floriculture; a botanical museum, for the exhibition of vegetable economic products; an herbarium, or collection of specimens of dried plants, scientifically arranged; finally, a library of botanical works. The South Park comprises about 1,200 acres, and the commis-

sioners will reserve for the Botanic Garden all the space which may be required for present and prospective use. Prof. H. H. Babcock has been chosen as Botanical Director.

## NOTES.

A. McDougall recently exhibited to the Manchester Philosophical Society a specimen of carbon which had formed upon the roof of a gas-retort, by the decomposition of the hydrocarbon gas by heat. This carbon resembles graphite, and its mode of formation might possibly explain that of graphite. The latter mineral always occurs in association with rocks which have been subjected to igneous action, and may have been formed by hydrocarbon gases traversing fissures, the sides of which were in a highly-heated state.

The adulteration of tobacco is extensively practised in England. A cigar-maker was recently found guilty of manufacturing cigars which contained 74 per cent. of lime-leaves, 7 per cent. of colored paper, and only 19 per cent. of tobacco.

Some one in Texas is examining the annual rings on trees with reference to the effect of very dry seasons upon tree-growth. He has a theory that a series of such seasons may return in regular periodicity, the discovery of which would be of great value to the farmer, since it would enable him to anticipate short crops, and, by previous surplus ones, prepare for them. He has selected for his purpose the burr-oak, on some of which he finds a record of the growth of three hundred years. So far as he has traced back human records, he finds each very dry season marked by rings of extraordinary thinness. He is still tracing back the records of man and Nature in the hope of discovering the law above referred to.—*Department of Agriculture.*

Antimony, equal to the best English, is produced in San Francisco from native ore, and might be sold there at a far lower price than the imported article. In practice, however, the California metal has to be shipped to New York, and then returned to San Francisco as *imported* antimony, consumers persisting in the belief that, unless it comes from England, it is of little value!

A Western farmer communicates to the *American Chemist* a method of preserving wooden posts, so that they will last longer than iron in the ground, while the cost does not exceed two cents per post. This is the recipe: Take boiled linseed-oil and stir into it pulverized charcoal to the consistency of paint, and put a coat of this over the timber.

The case of the *ecstatica*, Louise Lateau, who says that for years she has partaken of no food, has been considered in the Brussels Academy of Medicine. The opinion of the Academy is: "That Louise works and requires food. When she breathes, she exhales water-vapor and carbonic acid; her weight has not decreased since she has been observed; she therefore consumes carbon which is not furnished by her system. Whoever alleges that Louise Lateau is not subject to physiological laws, must prove it; until this is done physiology will pronounce the miracle a deception."

A new mammalian genus, *Mixocebus*, is described by Peters in the *Monatsberichte* of the Berlin Academy of Science. It is most nearly allied to *Lepidolemur*, and is covered with a brown fur, except the head and neck, which are of lighter color. The tail is longer than the body. The feet are, in shape, not unlike human hands, and the thumbs of all four feet are opposable. Habitat, Madagascar.

Sir Charles Lyell bequeathed to the British Geological Society £2,000 as a fund for the promotion of geological research. The award is to be accompanied by a "Lyell Medal," and to be open to geologists without distinction of nationality or of sex.

An International Congress of "Americanists" is to assemble at Nancy, France, on the 22d of July. The object is to bring together those who are interested in the history of America prior to its discovery by Columbus, and in the interpretation of the monuments and the ethnology of the aboriginal races.

At the Philadelphia Academy of Sciences, Mr. Willard gave two instances of the brittleness of iron under the low temperature of the past winter. In breaking up an old locomotive, the cutting off of the rivet-heads, which usually requires heavy sledging, was effected by a single blow. Again, in the forging of a long steamboat shaft of the best hammered iron, which hung balanced in a crane, the hammering of the heated end caused vibration in the other end, which caused the beam to break sharp near the point of support.

There are now manufactured in England candles containing in their substance some of those gum-resins and balsams, especially benzoin and storax, which have been found useful in chronic pulmonary and allied maladies. These "pulmonic candles" yield, on combustion, a pleasing fragrance, and at the same time give a good light.

All the steamers afloat on the Caspian Sea use petroleum exclusively for fuel, burning it with the aid of a blast of steam.

Canada rice-grass is said to afford an excellent material for the manufacture of paper. It is comparatively free from silicates, and the paper is quite as strong and flexible as that made from rags. It is easily bleached, pure in color, and presents a surface of perfect evenness. It also takes a very clear impression from the printer's types. The plant grows wild, and in great abundance, in the United States and Canada.

Experiments made by Dr. Chassaignol, of Brest, show that the flesh of drunkards is not more inflammable after death than the flesh of those who have been abstemious; even when soaked for several days in alcohol, it burns with difficulty.

To determine the true nature of the acid principle of gastric juice, the French physiologist Rabuteau took juice from the stomach of a dog which had been allowed to fast for twenty-four hours, and then fed on bits of tendon. To the filtered liquid he added as much quinia as it would dissolve. Then it was dried *in vacuo*, and the residue treated first with amylic alcohol, then with chloroform or benzine. On evaporation, a pure hydrochlorate of quinia was obtained. No trace of lactic acid was found.

Died, March 2d, Robert Willis, F. R. S., Professor of Natural and Experimental Philosophy in the University of Cambridge, England, for nearly forty years. Deceased had been President of the British Association, and at the time of his death was one of the Visitors of the Greenwich Observatory.

A pleasing illustration of the deep popular interest now almost universally taken in scientific research comes to us from Sweden. Dr. Berggren, a Swedish botanist, who had explored Spitzbergen in 1868, and Greenland in 1870, found himself last year in New Zealand without the means necessary for pursuing his investigations into the flora of that country. The situation was made public by a Swedish newspaper, and immediately the proprietors of another Swedish newspaper, *Göteborg's Post*, forwarded a large sum toward the prosecution of the work, and private contributions came in so rapidly that Dr. Berggren is now in possession of all the pecuniary aid he needs.

During the extreme cold of the past winter, the Messrs. Becquerel made observations on the effect of the presence or absence of turf on the temperature of the soil beneath the surface. Both of the soils under observation were covered with snow. It was found that, the temperature of the air being from 0° to 12° Cent., that of the turf-covered soil, at the depth of twenty inches, was never so low as zero, whereas in the case of denuded soil the temperature was nearly 5° below zero (Cent.).

Döring, a German physician, asserts that an average dose of four grammes of chloral hydrate suffices not only to procure rest and sleep in case of sea-sickness, but even to entirely cure the disorder.

Dr. J. D. Hooker, President of the British Royal Society, questions the expediency of recognizing scientific services and discoveries by such trivial rewards as *medals*. He favors some other form of award which might convey to the public a more prominent and a more permanent record of the services done by the recipients.

Prof. de Bary, of Strasburg, is inclined to believe that the *Peronospora infestans*, or parasitic fungus of the potato, passes a portion of its life upon some other plant. Probably both clover and straw are capable of entertaining the *Peronospora*. If this is the case, it gives confirmation to the prevailing opinion that barn-yard manure promotes potato-disease, especially when applied in spring. The theory can be easily tested.

A letter to the Department of Agriculture from San Joaquin County, California, states that hundreds of tons of the finest grapes were left on the vines in that county at the close of the past season, there being no demand for them. Wine-makers were paying only $15 per ton, and very few were buying even at that price.

It has been asserted that oxides of nitrogen may be produced by oxidation of atmospheric nitrogen through the agency of ozone, but, from experiments made by Prof. Carius, it appears that free nitrogen remains unacted on in the presence of this active oxygen. He believes that the most important reaction in Nature by which nitrates and nitrites are generated is the oxidation of ammonia by means of ozone.

During the visit of Prof. W. D. Whitney to England, this spring, the British Philological Society will hold a special meeting for the purpose of hearing a paper from him. Prof. Whitney has just finished a volume for the "International Scientific Series" on the "Life and Growth of Language."

An English sanitarian, Dr. Yeld, of Sunderland, contends for the superiority of sea-water over fresh water in street sprinkling, and alleges that when treated by the former the streets remain much longer moist even during very hot weather, and that by its means the cohesive power of the materials of a road is increased.

Dynamite is employed in France for the purpose of breaking up old cannon. The proportion of dynamite required for this purpose is only about one-thousandth part of the weight of the iron.

WILLIAM ROBERT GROVE.

THE

POPULAR SCIENCE MONTHLY.

JULY, 1875.

# ANENT ANTS.

By E. R. LELAND.

SINCE the earliest recorded observations of insect-life, the ant has been a subject of especial comment and wonderment. Found throughout the range of both temperate and the torrid zones, it is in the tropics that the most interesting species abound, and where their vast numbers and their industry and fearless pertinacity make them a veritable scourge.

Many confused, not to say fabulous, statements regarding them have been published in books of travels, and copied in natural history works; but enough has been recorded concerning them, which has the warrant of recent and high authority, to justify the views popularly held as to their intelligence and sagacity.

Mr. Bates, in "The Naturalist on the Amazon," devotes considerable space to them, and, in the descriptions following, very free use is made of his delightful book, and most of the illustrations are borrowed from that source.

One of the chief peculiarities of the ants is their social relations. Assembling in countless multitudes, they are divided into different classes, each with a special order of duties to fulfill, but all working harmoniously for a definite end—the perpetuation of the species. Their communities consist of males, females, and neuters; with generally two and sometimes three distinct orders or castes of the latter. Upon them devolves all the labor, the divisions being known as the worker-minors and the worker-majors, the brunt of the work falling upon the first, while the function of the worker-major, though not definitely understood, seems to be that of a superintendent or a soldier, or perhaps a combination of the two.

One of the most interesting of the American species is the saüba, or leaf-cutting ant (*Œcodoma cephalotes*). The workers of this species are of three orders, and vary in size from two to seven lines. Some idea of them may be obtained from the accompanying woodcut.

The true working-class of a colony is formed by the small-sized order of workers (1, Fig. 1). The two other kinds have enormously-swollen heads; in one of these the head is highly polished (2); in the other (3) it is opaque and hairy. The worker-minors vary greatly in size, some being double the bulk of others. The entire body is of solid consistence, and of a pale, reddish-brown color. The thorax, or middle segment, is armed with three pairs of sharp spines; the head also has a pair of similar spines proceeding from the cheeks behind.

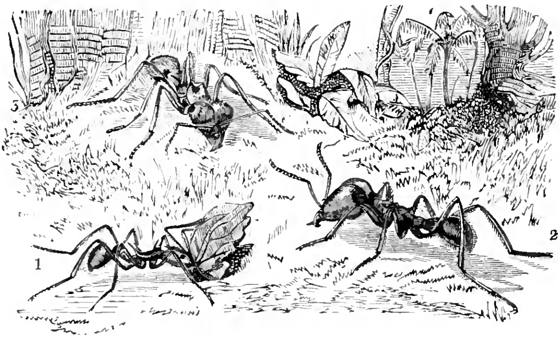


Fig. 1.—Saüba, or Leaf-cutting Ant.—1, Worker-minor; 2, Worker-major; 3, Subterranean Worker.

Their domes or outworks are very extensive, some of them being forty yards in circumference, but not more than two feet high. The entrances are small and numerous; in the large hillocks a great amount of excavation is required to get at the main galleries; the minor entrances converge at a few feet below the ground to one broad, elaborately-worked gallery or mine four or five inches in diameter. These underground abodes are very extensive. The Rev. Hamlet Clark relates that the saüba of Rio de Janeiro has excavated a tunnel under the bed of the river Parahyba, at a place where it is as broad as the Thames at London Bridge. At the Magoary Rice-Mills, near Pará, these ants once pierced the embankment of a large reservoir; the great body of water which it contained escaping before the damage could be repaired. One other fact is told of these ants, which shows the herculean nature of their labors. Their lives are dependent upon access to water, and they always choose places where it is to be obtained by digging wells. One case is related where a well was dug for domestic purposes, and water found at a depth of thirty feet; to do this, an ant-well was followed which was twelve inches in diameter.

The habit in this ant of clipping and carrying away immense quantities of leaves has long been recorded. When employed in this work, their processions look like a multitude of animated leaves on the march. They mount the trees in swarms. Each one places itself on the surface of a leaf, and cuts with its sharp, scissor-like jaws a nearly semi-

circular incision on the upper side; it then takes the edge between its jaws, and, by a sharp jerk, detaches the piece which is about the size of a dime. Sometimes they let the leaf drop to the ground, where a little heap accumulates, until carried off by another relay of workers; but generally each marches off with the piece it has operated upon, and, as all take the same road to their colony, the path they follow soon becomes smooth and bare, looking like the impression of a cart-wheel through the herbage. The heavily-laden workers troop up and cast their burdens on the hillock; another relay of laborers place the leaves in position, covering them with a layer of earthy granules, which are brought up one by one from the soil beneath. It has not been shown satisfactorily to what use the leaves are put. It was formerly supposed that they were consumed as food. Mr. Bates's investigations convinced him that the leaves were used to thatch the domes which cover the entrances to the subterranean dwellings, thereby protecting from the deluging rains the young broods in the nests beneath. Mr. Belt, however, who observed the leaf-cutting ants in Central America, and gives a full and interesting account of them in his "Naturalist in Nicaragua," arrives at the conclusion that the leaves which they gather in such enormous quantities are used to form beds for the growth of a minute fungus, on which they and their young live. Fritz Müller, writing from Brazil (*Nature*, vol. x., p. 102), says that he has always held this view, and that an examination of their stomachs under the microscope confirms it.

This ant is so abundant in some districts that agriculture is almost impossible, and wherever it exists it is a terrible pest. It is also troublesome to the inhabitants from its habit of plundering the stores of provisions in houses at night, for it is even more active by night than in the daytime.

The principal part of the visible work is done by the small-heads (1, Fig. 1), while those which have massive heads, the worker-majors (2), are generally observed to be simply walking about. They are not, in this species, soldiers, for they never fight. The function of superintendence would seem superfluous in a community where all work with precision. They cannot, however, be entirely useless to the community, for the sustenance of an idle class of such bulky individuals would be too heavy a charge for the species to sustain. Prof. Sennichrast, who studied some of the species of *Œcodoma* in Mexico, is of the opinion that their special *rôle*, if they have one, is borne in the excavation of the nest, and in tunneling the galleries, labors which require superior strength and better implements.

The third order of workers is the most curious. If the main shaft of a mine be probed, a small number of colossal fellows (3, Fig. 1) will slowly begin to make their way up the smooth sides of the mine. In the middle of the forehead is a trim *ocellus*, or simple eye, of quite different structure from the ordinary compound eye on the sides of the

head. This frontal eye is totally wanting in the other workers, and is not known in any other kind of ant. Their special functions are unknown. None of this species are pugnacious.

The work of reproduction begins with the rainy season. The union probably takes place in the night, for in the morning the neighborhood of the nest will be strewed with the females, and the dead bodies of the males, the former already fertile, from whom the workers make it their duty to tear away the wings. The true females are incapable of attending to the wants of their offspring; and it is on the poor, sterile workers, who are denied all the other pleasures of maternity, that the care devolves. The successful *début* of the winged males and females depends likewise on the workers. Great activity reigns in an ants'-nest on the exodus of the winged individuals. The workers clear the roads of exit, and show the most lively interest in their departure, although it is highly improbable that any of them will return to the same colony. They are of large size, the female measuring two and a quarter inches in expanse of wing; the male is not much more than half the size. They swarm in vast numbers, but are so eagerly preyed upon by insectivorous animals that but few of the impregnated females escape the slaughter to found new colonies. An immense amount of labor would be saved to the ants, if, instead of raising annually myriads of winged males and females to perish, they raised only a few wingless males and females, which, free from danger, might remain in their native nests; and, as Fritz Müller says, he who does not admit the paramount importance of intercrossing must of course wonder why the latter manner of reproduction has not long since taken the place, through natural selection, of the production of winged males and females. But the wingless individuals would of course have to pair always with their near relatives, while by swarming a chance is given for the intercrossing of individuals not nearly related.

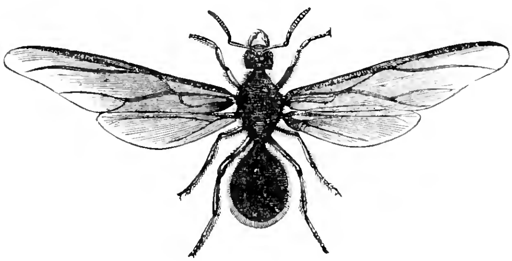

Fig. 2.—Saüba Ant, Female.

Resembling the saüba, in being vegetable-feeders, are the harvesting-ants (*Atta structor*, *A. barbara*, *Pheidole megacephala*, etc.). It has been a fashion among naturalists to set down as pure invention the accounts by classical writers of the accumulation of cereals by ants for winter consumption, and to assume that the Biblical injunction to

study the ways of her "who, having no guide, overseer, or ruler, provideth her meat in the summer, and gathereth her food in the harvests," was a figure drawn from careless observation; that ants, being carnivorous insects, would not eat dry, hard grains of wheat or barley, the idea that they would do so having arisen from mistaking the whitish cocoons which inclose the pupæ for grains of wheat, to which they bear a resemblance. But Mr. Traherne Moggridge has recently, by careful observation in the south of Europe, confirmed in many of their minutest details the accounts given by ancient writers, and shown that, in treating these accounts with contempt, it is the modern authors who have been guilty of forming hasty conclusions from insufficient data.

The ants were described as ascending the stalks of cereals and gnawing off the grains, while others below detached the seed from the chaff and carried it home; as gnawing off the radicle to prevent germination, and spreading their stores in the sun to dry after wet weather. These statements Mr. Moggridge has verified, supplementing them by discovering the granaries in which they are stored, sometimes excavated in solid rock. He has seen them in the act of collecting seeds, and has traced seeds to the granaries; he has seen them bring out the grains to dry after a rain, and nibble off the radicle from those which were germinating; lastly, he has seen them feed on the seeds so collected. A curious point is, that the collections of seeds, although stored in damp situations, very rarely germinate; yet nothing has been done to deprive them of vitality, for, on being sown, they grow vigorously. Their depredations are of such extent as must cause serious loss to cultivators.

Texas and Northern Mexico furnish a remarkable species in the honey-making ants (*Myrmecocystus Mexicanus*). The workers of their communities are divided into three classes: 1. Yellow workers, nurses and feeders; 2. Yellow workers, honey-makers; 3. Black workers, guards and purveyors.

The site chosen for their nest is usually some sandy soil in the neighborhood of shrubs and flowers, the space occupied being four or five feet square. The black workers surround the nests as guards, and are always in a state of great activity. They form two lines of defense, moving different ways, their march always being along three sides of a square; one column moving from the southeast to the southwest corners of the fortification, while the other proceeds in the opposite direction. Most of the nests lie open to the south; the east, west, and northern sides, being surrounded by the soldiers. In case of an enemy approaching, a number of guards sally forth to meet the intruder. Spiders, wasps, beetles, and other insects are, if they come too near the hive, savagely attacked, and the dead bodies speedily removed from the neighborhood, the soldiers at once resuming their places in the line.

Their object in destroying other insects is protection of the encampment, and not the obtaining of food. While one section of the black workers is thus engaged, a more numerous division will be found employed in entering the quadrangle by a diagonal line, bearing northeast, and carrying flowers and fragments of aromatic leaves, which they deposit in the centre of the square.

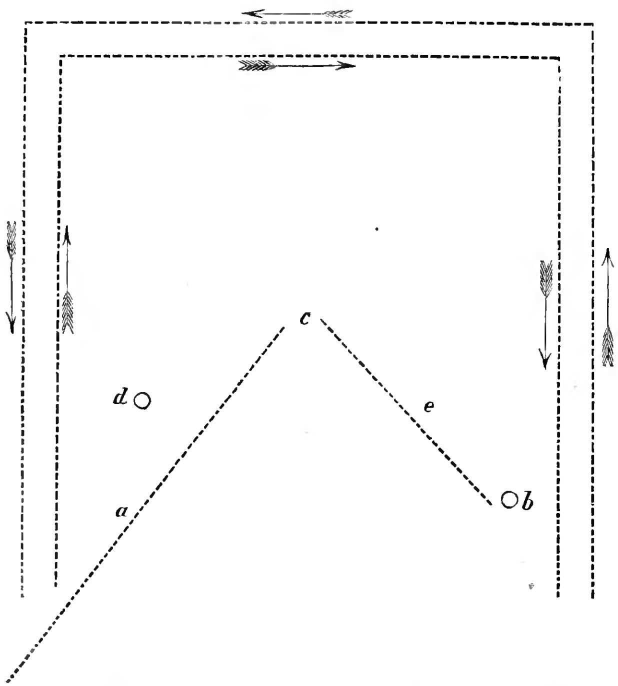


Fig. 3.—Encampment of the Honey-making Ant (*Myrmecocystus Mexicanus*).

The line *a* of the sketch shows the path of this latter section, the mound of flowers and leaves being at *c*. This line leads to the shrubs, upon which another division of the black workers is settled, engaged in cutting off the leaves and petals to be conveyed to the nest. On the west side of the encampment is a hole marked *d*, leading to the interior of the nest. It is probably intended for the introduction of air, as, in case of any individuals carrying their loads into it, they immediately emerge and carry them to the common heap, as if conscious of having made a mistake. A smaller hole, near the southeast corner of the square, is the only other means by which the interior can be reached; and down this aperture, *b*, the flowers gathered by the black workers are carried along the line *e* from the heap in the centre of the square, by a number of the small yellow workers, who seem adapted for the gentler office of nurses for the colony within. No black ant is

ever seen on the line *e*, and no yellow one ever approaches the line *a*, each keeping his own station, and following his given line of duty with a steadfastness which is remarkable.

When the course of the galleries is traced from the entrances, a small excavation is reached, across which is stretched, in the form of a spider's web, a net-work of squares about one-quarter inch across, the ends of the web being fastened firmly to the earth of the sides of the cell. In each one of the squares, supported by the web, sits one of the honey-making workers—prisoners, for locomotion is impossible, the distended abdomen which constitutes the honey-bag being at least twenty times as large as the rest of the body. The workers provide them a constant supply of flowers and pollen, which, by a process analogous to that of the bee, they convert into honey. Whether the honey-makers are themselves used as food, or excrete their saccharine fluid, and then proceed to distill more, is not known. Indeed, that the remainder of the inhabitants feed on the supply thus obtained in any manner, although surmised, has not been established, very little being known of the economy of these creatures.

The honey is much sought after by the Mexicans, who not only use it as a delicate article of food, but ascribe to it great healing properties.

The worst insect pest of tropical America is the terrible fire-ant (*Myrmica sævissima*), whose sting is likened to the puncture of a red-hot needle. It is found only on sandy soils in open places, and seems to thrive most near houses and in weedy villages. Towns are sometimes deserted on account of this little tormentor. It is a small species, of a shining red color, not greatly differing from the common red stinging-ant of our own country, except that the pain and irritation caused by its sting are much greater. Where it abounds, the whole soil is undermined by it; the ground is perforated with the entrances to their subterranean galleries, and a little sandy dome occurs here and there where the insects bring their young to receive warmth near the surface. Homes are overrun with them; they dispute every fragment of food with the inhabitants, and destroy clothing for the sake of the starch. All eatables have to be suspended in baskets from the rafters, and the cords well soaked with copaiba-balsam, which is the only means known to prevent them from climbing. They seem to attack persons out of sheer malice. The legs of tables, chairs, and stools, and the cords of hammocks, have to be smeared in the same way.

Belonging to a totally different group are the *Ecitons*, or foraging-ants; they are carnivorous, and hunt in vast armies, exciting terror wherever they go, resembling in their habits the often-described drivers of tropical Africa, though belonging to quite another sub-group of the ant tribe. They are composed, besides males and females, of two classes of workers—a large-headed and a small-headed

class; the large-heads have, in some species, greatly-lengthened jaws; the small-heads have jaws always of the ordinary shape, but the two classes are not sharply defined in structure and function, except in two species. In these the jaws of the worker-majors are so monstrously lengthened that they are incapacitated for taking part in the labors of the worker-minors, and act as soldiers. The peculiar feature in the habits of the genus *Eciton* is their hunting for prey in regular bodies or armies. It is this which chiefly distinguishes them from the genus *Myrmica*, the common red stinging-ant of the temperate zone, whose habit is to search for food in the usual irregular manner. All the *Ecitons* hunt in large organized bodies; but almost every species has its own special manner of hunting.

Eciton Legionis.—In this species there is no division in classes among its workers, although the difference in size is very great. It lives in open places, and its movements are easy to be observed; its sting and bite are not very formidable. The armies consist of thousands of individuals, and move in rather broad columns. They are quick to break line on being disturbed, and attack hurriedly and furiously any intruding object. Their activity seems to be chiefly directed to plundering the nests of a large defenseless ant of another genus (*Formica*).

Eciton Drepanophara.—This, one of the commonest species of foraging-ants, confines its ravages to the thickest part of the forest. When a pedestrian falls in with one of their trains, the first signal given him is a twittering and restless movement of small flocks of plain-colored birds (ant-thrushes) in the jungle. If this be disregarded, and he advances a few steps farther, he is sure to fall into trouble, and find himself suddenly attacked by numbers of the ferocious little creatures. They swarm up his legs with incredible rapidity, each one driving his pincer-like jaws into his skin, and, with the purchase thus obtained, doubling its tail and stinging with all its might. There is no course left but to run for it. The tenacious insects then have to be plucked off, one by one, a task which is generally not accomplished without pulling them in twain, and leaving heads and jaws sticking in the wounds.

The errand of the vast ant-armies is plunder. Wherever they move, the whole animal world is set in commotion, and every creature tries to get out of their way. It is especially wingless insects that have cause to fear, such as heavy-bodied spiders, maggots, caterpillars, larvæ of cockroaches, etc., all of which live under fallen leaves, or in decaying wood. The main column, from four to six deep, moves forward in a given direction, clearing the ground of all animal matter, dead or alive, and throwing out here and there a thinner column to forage for a short time on the flanks of the main army. If some rich place be encountered, for example, a mass of rotten wood abounding in insect-larvæ, a delay takes place, and a very strong force is concen-

trated upon it. The excited creatures search every cranny, and tear in pieces all the grubs they bring to light. They attack wasps'-nests, when built on low shrubs, gnawing away the paper covering to get at the larvæ, pupæ, and newly-hatched wasps, and cut every thing to tatters, regardless of the infuriated owners which are flying about them.

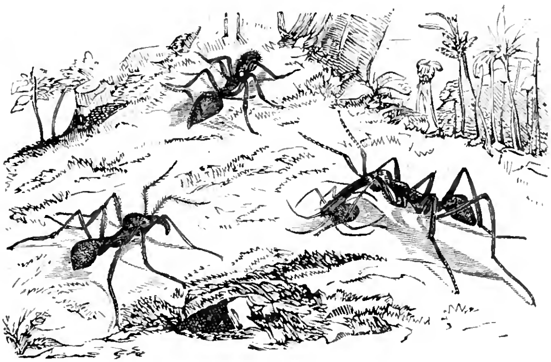

Fig. 4.—Foraging-Ants (*Eciton drepanophara*).

The life of the *Ecitons* is not all work, however; they seem frequently to be employed in a way that looks like recreation. This always takes place in a sunny nook. The main column of the army and the branch columns are in their ordinary relative positions; but, instead of pressing forward eagerly and plundering right and left, they seem to be smitten with a sudden fit of laziness. Some walk slowly about; others brush their antennæ with their fore-feet; but the drollest sight is their cleaning one another. Here and there an ant may be seen, stretching forth first one leg and then another, to be brushed and washed by one or more of its comrades, who perform the task by passing the limb between the jaws and the tongue, finishing by giving the antennæ a friendly wipe. It is a curious spectacle, and well calculated to increase one's amazement at the similarity between the actions of ants and the acts of rational beings—a similarity which must have been brought about by different processes of development of the primary qualities of mind. The action of these ants looks like simple indulgence in idle amusement. Have these little creatures, then, an excess of energy, and do they expend it in mere sportiveness, like young kittens, or in idle whims, like rational beings?

Eciton Prædator.—This species differs from other *Ecitons*, chiefly from its habit of hunting, not in columns, but in dense phalanxes consisting of myriads of individuals. A phalanx, when passing over smooth ground, occupies a space from four to six yards square. Nothing in insect-movements is more striking than this rapid march of these large compact bodies.

Blind Ecitons.—None of the foregoing kinds have eyes of the

faceted or compound structure, such as are usual in insects, and which ordinary ants (*Formica*) are furnished with; but all are provided with organs of vision, composed each of a single lens. Connecting them with the utterly blind species of the genus, is a very stout-limbed *Eciton*, the *E. crassicornis*, whose eyes are sunk in deep sockets. This ant goes on foraging expeditions like the rest of its tribe, but it avoids the light, always moving in concealment under leaves and fallen branches. When its columns have to cross a cleared space, the ants construct a temporary covered way with granules of earth, arched over, and holding together mechanically; under this the procession passes in secret, the indefatigable creatures repairing their arcade as fast as breaches are made in it.

Next in order comes the *E. vastator*, which has no eyes, though the collapsed sockets are plainly visible; and, lastly, the *E. erratica*, in which both sockets and eyes have disappeared, leaving only a faint ring to mark the place. The armies of *E. vastator* and *E. erratica* move wholly under covered roads, constructing them rapidly as they advance. The column of foragers pushes forward, step by step, under the protection of these covered ways, and, on reaching a rotten log, or other promising hunting-ground, pour into the crevices in search of booty. The grains of earth for their arcades are taken from the soil over which the column is passing, and are fitted together without cement.

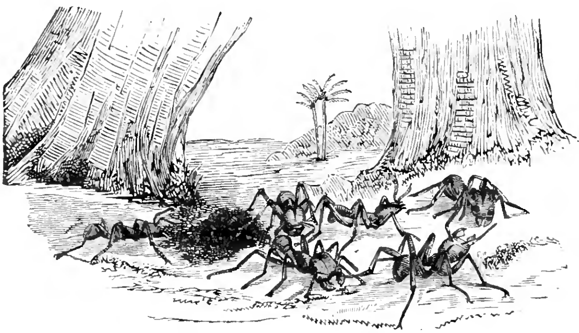

Fig. 5.—Foraging-Ants (*Eciton erratica*), constructing a Covered Road—Soldiers sallying out on being disturbed.

Working in numbers, they build up simultaneously the sides of their convex arcades, and contrive in a surprising manner to approximate them and fit in the key-stone without letting the loose, uncemented structure fall to pieces. There is a very clear division of labor between the two classes of neuters in these blind species. When a breach is made in one of their covered ways, all the ants underneath are set in commotion, but the worker-minors remain behind to repair the damage, while the large-heads issue forth in a most menacing manner, rearing their heads, and snapping their jaws with an expres-

sion of fiercest rage and defiance. Pitched battles sometimes occur between different pugnacious species, and classical writers have deemed them worthy to be recorded. Kirby and Spence relate that "Æneas Sylvius, after giving a circumstantial account of one contested with great obstinacy by a large and a small species, adds that 'this action was fought in the Pontificate of Eugenius IV.'" Thoreau gives a graphic description—in his whimsical style of exalting small things and emphasizing the trifling difference that there is between big and little actors and events in Nature—of a similar engagement that took place near his hut "in the presidency of Polk, five years before the passage of Webster's Fugitive Slave Bill" ("Walden," p. 346).

Whether such an enactment obtains in any of the ant nations is unknown, but that certain of them possess the extraordinary instinct of capturing the pupæ of other species and bringing them up as slaves, is a well-authenticated fact. They are made captive while still in the cocoon, and on emerging become the auxiliary workers and friends of their captors, as though such was their natural destiny.

But no fanciful exaggeration is needed to impress us with the degree of forethought, methodical industry, and dauntless courage, the engineering and mechanical skill, the reasoning and perceptive powers and general sagacity which the ant displays.

If space permitted, numerous illustrative citations could be given. A member of the Natural History Society describes a tubular bridge, half an inch in diameter, and spanning a chasm twelve inches across. A correspondent of Mr. Darwin's, Mr. Joseph D. Hague, a geologist of California, submits what seems to be satisfactory evidence that they realize danger from seeing the corpses of their fellows, an inference drawn by no other invertebrate, if indeed it be by the higher animals.

They keep domestic animals. The aphides, or plant-lice, excrete a peculiar sweet fluid which the ant obtains by caressing the abdomen of the aphis with its antennæ. Ordinarily they seek the aphides upon plants, but that they also keep them in their nests much as man keeps cows, is an opinion which receives the sanction of eminent naturalists, among them Sir John Lubbock, who further says: "Ants also keep a variety of beetles and other insects in their nests. That they have some reason for this seems clear, because they readily attack any unwelcome intruder; but what that reason is we do not yet know. If these insects are domesticated by the ants, then we must admit that the ants possess more domestic animals than we do."

Indeed, their whole social economy is of a complex order. Nowhere is the division of labor—which in mankind always marks a high state of civilization—so rigid, being carried to the extreme of a physical modification of great numbers of the community for the better fulfillment of their duties. Their undeveloped sterile females may serve to warn—or to encourage—those members of the *Anthropidæ*

who are so anxious to subordinate, if not wholly lay down, the gentle functions of maternity in order that they may engage in the sterner work of the world!

When, marking their size, we consider the mighty character of the works which they complete; when we reflect upon the infinitesimal ganglion which is the seat of the intelligence they display, we may well be filled with surprise, and almost wonder if man, or any other order of the vertebrata, is destined to remain forever the higher animal!

## THE FIRST AND THE LAST CATASTROPHE.

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I PROPOSE in this lecture to consider speculations of quite recent days about the beginning and the end of the world. The world is a very interesting thing, and I suppose that from the earliest times that men began to form any coherent idea of it at all, they began to guess in some way or other how it was that it all began, and how it was all going to end. But there is one peculiarity about these speculations which I wish now to consider, that makes them quite different from the early guesses of which we read in many ancient books. These modern speculations are attempts to find out how things began, and how they are to end, by consideration of the way in which they are going on now. And it is just that character of these speculations that gives them their interest for you and for me; for we have only to consider these questions from the scientific point of view. By the scientific point of view, I mean one which attempts to apply past experience to new circumstances according to an observed order of Nature. So that we shall only consider the way in which things began, and the way in which they are to end, in so far as we seem able to draw inferences about those questions from facts which we know about the way in which things are going on now. And, in fact, the great interest of the subject to me lies in the amount of illustration which it offers of the degree of knowledge which we have now attained of the way in which the universe is going on.

The first of these speculations is one set forth by Prof. Clerk Maxwell, in a lecture on "Molecules," delivered before the British Association at Bradford. By a coincidence, which to me is a happy one, at this moment Prof. Maxwell is lecturing to the Chemical Society of London upon the evidences of the molecular constitution of matter. Now, this argument of his, which he put before the British Association at Bradford, depends entirely upon the modern theory of the molecular constitution of matter. I think this the more important,

because a great number of people appear to have been led to the conclusion that this theory is very similar to the guesses which we find in ancient writers—Democritus and Lucretius. It so happens that these ancient writers did hold a view of the constitution of things which in many striking respects agrees with the view which we hold in modern times. This parallelism has been brought recently before the public by Prof. Tyndall in his excellent address at Belfast. And it is perhaps on account of the parallelism, which he pointed out at that place, between the theories held among the ancients and the theory now held among the moderns, that many people who are acquainted with classic literature have thought that a knowledge of the views of Democritus and Lucretius would enable them to understand and criticise the modern theory of matter. That, however, is a mistake. The difference between the two is mainly this: the atomic theory of Democritus was a guess, and no more than a guess. Every body around him was guessing about the origin of things, and they guessed in a great number of ways; but he happened to make a guess which was more near the right thing than any of the others. This view was right in its main hypothesis, that all things are made up of elementary parts, and that the different properties of different things depend rather upon difference of arrangement than upon ultimate difference in the substance of which they are composed. Although this was contained in the atomic theory of Democritus, as expounded by Lucretius, yet it will be found by any one who examines further the consequences which are drawn from it, that it very soon diverges from the truth of things, as we might naturally expect it would. On the contrary, the view of the constitution of matter which is held by scientific men in the present day is not a guess at all.

In the first place, I will endeavor to explain what are the main points in this theory. First of all we must take the simplest form of matter, which turns out to be a gas—such, for example, as the air in this room. The belief of scientific men in the present day is that this air is not a continuous thing, that it does not fill the whole of the space in the room, but is made up of an enormous number of exceedingly small particles. There are two sorts of particles: one sort of particle is oxygen, and another sort of particle nitrogen. All the particles of oxygen are as near as possible alike in these two respects: first in weight, and secondly in certain peculiarities of mechanical structure. These small molecules are not at rest in the room, but are flying about in all directions with a mean velocity of seventeen miles a minute. They do not fly far in one direction; but any particular molecule, after going over an incredibly short distance—the measure of which has been made—meets another, not exactly plump, but a little on one side, so that they behave to one another somewhat in the same way as two people do who are dancing Sir Roger de Coverley; they join hands, swing round, and then fly away in different

directions. All these molecules are constantly changing the direction of each other's motion; they are flying about with very different velocities, although, as I have said, their mean velocity is about seventeen miles a minute. If the velocities were all marked off on a scale, they would be found distributed about the mean velocity just as shots are distributed about a mark. If a great many shots are fired at a target, the hits will be found thickest at the bull's-eye, and they will gradually diminish as we go away from that, according to a certain law, which is called the law of error. It was first stated clearly by Laplace; and it is one of the most remarkable consequences of this theory that the molecules of a gas have their velocities distributed among them precisely according to this law of error. In the case of a liquid, it is believed that the state of things is quite different. We said that in the gas these molecules are moved in straight lines, and that it is only during a small portion of their motion that they are deflected by other molecules; but in a liquid we may say that the molecules go about as if they were dancing the grand chain in the Lancers. Every molecule after parting company with one finds another, and so is constantly going about in a curved path, and never gets quite clear away from the sphere of action of the surrounding molecules. But, notwithstanding that, all molecules in a liquid are constantly changing their places, and it is for that reason that diffusion takes place in the liquid. Take a large tank of water and drop a little iodine into it, and you will find after a certain time all the water turned slightly blue. That is because all the iodine-molecules have changed like the others and spread themselves over the whole of the tank. Because, however, you cannot see that, except where you use different colors, you must not suppose that it does not take place where the colors are the same. In every liquid all the molecules are running about and continually changing and mixing themselves up in fresh forms. In the case of a solid quite a different thing takes place. In a solid every molecule has a place which it keeps; that is to say, it is not at rest any more than a molecule of a liquid or a gas, but it has a certain mean position which it is always vibrating about and keeping fairly near to, and it is kept from losing that position by the action of the surrounding molecules. These are the main points of the theory of the constitution of matter as at present believed. It differs from the theory of Democritus in this way. There is no doubt that in the first origin of it, when it was suggested as a whole, it was a guess of his.

In order to make out that your supposition is true, it is necessary to show, not merely that that particular supposition will explain the facts, but also that no other one will. Now, by the efforts of Clarges and Prof. Clerk Maxwell, the molecular theory of matter has been put in that other position, namely, instead now of saying, "Let us suppose that such and such things are true," and then deducing

from that supposition what these consequences ought to be, and showing that these consequences are just the facts which we observe—instead of doing that, I say, we make certain experiments, we show that certain facts are undoubtedly true, and from these facts we go back by a direct chain of logical reasoning, which there is no way of getting out of, to the statement that all matter is made up of separate pieces or molecules, and that in matter of a given kind, in oxygen, or in hydrogen, or in nitrogen, these molecules are of very nearly the same weight, and have certain mechanical properties which are common to all of them. In order to show you something of the kind of evidence for that statement, I must mention another theory which, as it seems to me, is in the same position, that is the doctrine of the luminiferous ether, or that wonderful substance which is distributed all over space, and which carries light and radiant heat. By means of certain experiments upon interference, we can show, not by any hypothesis, not by any guess at all, but by a pure interpretation of the experiment—we can show that in every ray of light there is some change or other, whatever it is, which is periodic in time and in place. By saying it is periodic in time, I mean that at a given point of the ray of light this change increases up to a certain point, then decreases, then increases in the other direction, and then decreases again. That is shown by experiments of interference; it is not a theory which will explain the facts, but it is a fact which is got out of observation. By saying that this phenomenon is periodic in space, I mean that, if at any given instant you could examine the ray of light, you would find that some change or disturbance, whatever it is, has taken place all along it in different degrees. It vanishes at certain points, and between these it increases gradually to a maximum on one side and the other alternately. That is to say, in traveling along a ray of light there is a certain change (which can be observed by experiments, by operating upon a ray of light with other rays of light), which goes through a periodic variation in amount. The height of the sea, as you know if you travel along it, goes through certain periodic changes; it increases and decreases, and increases and decreases again at definite intervals. And if you take the case of waves traveling over the sea, and place yourself at a given point, say you put a cork upon the surface, you will find that the cork will rise up and down, that is to say, there will be a change or displacement of the cork's position, which is periodic in time, which increases and decreases, then increases in the opposite direction, and decreases again. Now, this fact, which is established by experiment, and which is not a guess at all, the fact that light is a phenomenon, periodic in time and space, is what we call the wave-theory of light. The word theory here does not mean a guess; it means an organized account of the facts, such that from it you may deduce results, which may be applicable to future experiments, the like of which have not yet been

made. But we can see more than this. So far we say that light consists of waves, merely in the sense that it consists of some phenomenon or other which is periodic in time and in place; but we know that a ray of light is capable of doing work. Radiant heat, for example, striking on a body, will warm it and enable it to do work by expansion; therefore this periodic phenomenon which takes place in the ray of light is something or other which possesses mechanical energy, which is capable of doing work. We may make it, if you like, a mere matter of definition, and say, "Any change which possesses energy is a motion of matter;" and this is perhaps the most intelligible definition of matter that we can frame. In that sense, and in that sense only, it is a matter of demonstration, and not a matter of guess, that light consists of the periodic motion of matter which is between the luminous object and our eyes. But that something is not matter in the ordinary sense of the term, it is not made up of such molecules as gases and liquids and solids are made up of. This last statement, again, is no guess, but a proved fact.

There are people who ask, "Why is it necessary to suppose a luminiferous ether to be any thing else except molecules of matter in space, in order to carry light about?" The answer is a very simple one. In order that separate molecules may carry about a disturbance, it is necessary that they should travel at least as fast as the disturbance travels. Now we know, by means that I shall afterward come to, that the molecules of gas travel at a very ordinary rate, about twenty times as fast as a good train. But, on the contrary, we know by the most certain of all evidence, by five or six different means, that the velocity of light is 200,000 miles a second. By that very simple means we are able to tell that it is quite impossible for light to be carried by the molecules of ordinary matter, and that it wants something else that lies between those molecules to carry the light. Now, remembering the evidence which we have for the existence of this ether, let us consider another piece of evidence, let us now consider what evidence we have that the molecules of a gas are separate from one another and have something between them. We find out by experiment, again, that the different colors of light depend upon the various rapidity of these waves, depend upon the size and upon the length of the waves that travel through the ether, and that when we send light through glass or any transparent medium except a vacuum, the waves of different lengths travel with different velocities. That is the case with the sea; we find that long waves travel faster than small ones. In much the same way, when light comes out of a vacuum and impinges upon any transparent medium, say upon glass, we find that the rate of transmission of all the light is diminished, that it goes slower when it gets inside of a material body; and that this change is greater in the case of large waves than of small ones. The small waves correspond to blue light and the large waves correspond

to red light. The waves of red light are not made to travel so slowly as the waves of blue light, but, as in the case of waves traveling over the sea, when light moves in the interior of a transparent body the large waves travel quickest. Well, then, by using such a body as will separate out the different colors—a prism—we are able to affirm what are the constituents of the light which strikes upon it. The light that comes from the sun is made up of waves of various lengths; but making it pass through a prism we can separate it out into a spectrum, and in that way we find a band of light instead of a spot coming from the sun, and to every band in the spectrum corresponds a wave of a certain definite length and definite time in vibration. Now we come to a very singular phenomenon. If you take a gas such as chlorine and interpose it in the wave of that light, you will find that certain particular rays of the spectrum are absorbed, while others are not. Now, how is it that certain particular rates of vibration can be absorbed by this chlorine gas while others are not? That happens in this way, that the chlorine gas consists of a great number of very small structures, each of which is capable of vibrating internally. Each of these structures is complicated, and is capable of a change of relative position among its parts of a vibratory character. We know that molecules are capable of such vibrations, such internal vibrations, for this reason, that if we heat any solid body sufficiently it will in time give out light; that is to say, the molecules are got into such a state of vibration that they start the ether vibrating, and they start the ether vibrating at the same rate at which they vibrate themselves. So that what we learn from the absorption of certain particular rays of light by chlorine gas, is that the molecules of that gas are structures which have certain natural rates of vibration, precisely those rates of vibration which belong to the molecules naturally. If you sing a certain note to a string of a piano, that string if in tune will vibrate. If, therefore, a screen of such strings were put across a room, and you sang a note on one side, a person on the other side would hear the note very weakly or not at all, because it would be absorbed by the strings; but if you sang another note, not one to which the strings naturally vibrated, then it would pass through, and would not be eaten up by setting the strings vibrating. Now this question arises. Let us put the molecules aside for a moment. Suppose we do not know of their existence, and say, "Is this rate of vibration, which naturally belongs to the gas, a thing which belongs to it as a whole, or does it belong to separate parts of it?" You might suppose that it belongs to the gas as a whole. A jar of water, if you shake it, has a perfectly definite time in which it oscillates, and that is very easily measured. That time of oscillation belongs to the jar of water as a whole. It depends upon the weight of the water, and the shape of the jar. But now, by a very certain method, we know that the time of vibration which corresponds to a certain definite gas

does not belong to it as a whole, but belongs to the separate parts of it, for this reason: that if you squeeze the gas you do not alter the time of vibration. Let us suppose that we have a great number of fiddles in a room which are all in contact, and have strings accurately tuned to vibrate to certain notes. If you sang one of those notes all the fiddles would answer; but if you compress them you clearly put them all out of tune. They are all in contact, and they will not answer to the tune with the same precision as before. But if you have a room which is full of fiddles placed at a certain distance from one another, then if you bring them within shorter distances of one another, so that they still don't touch, they will not be put out of tune, they will answer exactly to the same note as before. We see, therefore, that since compression of a gas within certain limits does not alter the rate of vibration which belongs to it, that rate of vibration cannot belong to the body of gas as a whole, but it must belong to the individual parts of it. Now by such reasoning as this it seems to me that the modern theory of the constitution of matter is put upon a basis which is absolutely independent of hypothesis. The theory is simply an organized statement of the facts, a statement, that is, which is rather different from the experiments, being made out from them in just such a way as to be most convenient for finding out from them what will be the results of other experiments. That is all we mean at present by scientific theory.

Upon this theory Prof. Clerk Maxwell founded a certain argument in his lecture before the British Association at Bradford. It is a consequence of the molecular theory, as I said before, that all the molecules of a certain given substance, say oxygen, are as near as possible alike in two respects—first in weight, and secondly in their times of vibration. Now Prof. Clerk Maxwell's argument was this: He first of all said that the theory required us to believe not that these molecules were as near as may be alike, but that they were exactly alike in these two respects—at least the argument appeared to me to require that. Then he said all the oxygen we know of, whatever processes it has gone through—whether it is got out of the atmosphere, or out of some oxide of iron or carbon, or whether it belongs to the sun, or the fixed stars, or the planets, or the nebulæ—all this oxygen is alike. And all these molecules of oxygen we find upon the earth must have existed unaltered, or unappreciably unaltered, during the whole of the time the earth has been evolved. Whatever vicissitudes they have gone through, how many times they have entered into combination with iron or silver and been melted down beneath the crust of the earth, or deoxidized and sent up again through the atmosphere, they have remained steadfast to their original form unaltered, the monuments of what they were when the world began. Now, Prof. Clerk Maxwell argues that things which are unalterable, and are exactly alike, cannot have been formed by any natural

process. Moreover, being exactly alike, they cannot have existed forever, and therefore they must have been made. As Sir John Herschel said, "they bear the stamp of the manufactured article."

Now, into these further deductions I do not propose to enter at all. I confine myself strictly to the first of the deductions which Prof. Clerk Maxwell made upon this theory. He said that because these molecules are exactly alike, and because they have not been in the least altered since the beginning of time, therefore they cannot have been produced by any process of evolution. It is just that question which I want to discuss. I want to consider whether the evidence that we have to prove that these molecules are exactly alike is sufficient to make it impossible that they can have been produced by any process of evolution. The position, that this evidence is not sufficient, is evidently by far the easier to defend, because the negative is proverbially hard to prove; and, if any one should prove that a process of evolution was impossible, it would be an entirely unique thing in science and philosophy. In fact, we may see from this example precisely how great is the influence of authority in matters of science.

If there is any name among contemporary natural philosophers to whom is due the reverence of all true students of science, it is that of Prof. Clerk Maxwell. But if any one, not possessing his great authority, had put forward an argument founded apparently upon a scientific basis, in which there occurred assumptions about what things can and what things cannot have existed from eternity, and about the exact similarity of few or more things established by experiment, we should say, "Past eternity; absolute exactness;" and we should pass on to another book. The experience of all scientific culture, for all ages during which it has been a light to men, has shown us that we never do get at any conclusions of that sort. We do not get at conclusions about infinite time or infinite exactness. We get at conclusions which are as nearly true as experiment can show, and sometimes which are a great deal more correct than direct experiment can be, so that we are able actually to correct one experiment by deductions from another; but we never get at conclusions which we have a right to say are absolutely exact; so that, even if we find a man of the highest powers saying that he had reason to believe a certain statement to be exactly true, or that he believed a certain thing to have existed from the beginning exactly as it is now, we must say, "It is quite possible that a man of so great eminence may have found out something which is entirely different from the whole of our previous knowledge, and the thing must be inquired into. But, notwithstanding that, it remains a fact that this piece of knowledge will be absolutely of a different kind from any thing that we knew before."

Now, let us examine the evidence by which we know that the molecules of the same gas are as near as may be alike in weight and in rates of vibration. There were experiments made by Dr. Graham,

late Master of the Mint, upon the rate at which different gases were mixed together. He found that if he divided a vessel by a thin partition made of black-lead or graphite, and put different gases on the two opposite sides, they would mix together nearly as fast as though there was nothing between them. The difference was, that the plate of graphite made it more easy to measure the rate of mixture; and Dr. Graham made measurements and came to conclusions which are exactly such as are required by the molecular theory. It is found by a process of mathematical calculation that the rate of diffusion of different gases depends upon the weight of the molecules. Now, a molecule of oxygen is sixteen times as heavy as a molecule of hydrogen, and it is found upon experiment that hydrogen goes through a septum or wall of graphite four times as fast as oxygen does. Four times four are sixteen. We express that rule in mathematics by saying that the rate of diffusion of gas is inversely as the square root of the mass of its molecules. If one molecule is thirty-six times as heavy as another—the molecule of chlorine is nearly that multiple of hydrogen—it will diffuse itself at one-sixth of the rate.

This rule is a deduction from the molecular theory, and it is found, like innumerable other such deductions, to come right in practice. But now observe what is the consequence of this. Suppose that, instead of taking one gas and making it diffuse itself through a wall, we take a mixture of two gases. Suppose we put oxygen and hydrogen into a vessel which has one side of it made of graphite, and we exhaust the air from the other side, then the hydrogen will go through this wall four times as fast as the oxygen will. Consequently, as soon as one side is full there will be a great deal more hydrogen in it than oxygen—that is to say, that we shall have sifted the oxygen from the hydrogen, not completely, but in a great measure, precisely as by means of a screen we can sift large coals from small ones. Now, suppose, when we have oxygen gas unmixed with any other, the molecules are of two sorts and of two different weights. Then you see that if we make that gas pass through a porous wall, the lighter particles would pass through first, and we should get two different specimens of oxygen gas, in one of which the molecules would be lighter than in the other. The properties of one of these specimens of oxygen gas would necessarily be different from those of the other, and that difference might be found by very easy processes. If there were any perceptible difference between the average weight of the molecules on the two sides of the septum, there would be no difficulty in finding that out. No such difference has ever been observed. If we put any single gas into a vessel, and we filter it through a septum of black-lead into another vessel, we find no difference between the gas on one side of the wall and the gas on the other side. That is to say, if there is any difference it is too small to be perceived by our present means of observation. It is upon that sort of evidence that the state-

ment rests that the molecules of a given gas are all very nearly of the same weight. Why do I say *very nearly?* Because evidence of that sort can never prove that they are exactly of the same weight. The means of measurement we have got may be exceedingly correct, but a certain limit must always be allowed for deviation; yet if the deviation of molecules of oxygen from a certain standard of weight were very small, and restricted within small limits, it would be quite possible for our experiments to give us the results which they do now. Suppose, for example, the variation in the size of the oxygen-atoms was as great as that in the weight of different men, then it would be very difficult indeed to tell by such a process of sifting what that difference was, or in fact to establish that it existed at all. But, on the other hand, if we suppose the forces which originally caused all those molecules to be so nearly alike as they are, to be constantly acting and setting the thing right as soon as by any sort of experiment we set it wrong, then the small oxygen-atoms on one side would be made up to their right size, and it would be impossible to test the difference by any experiment which was not quicker than the processes by which they were made right again.

There is another reason why we are obliged to regard that experiment as only approximate, and as not giving us any exact results. There is very strong evidence, although it is not conclusive, that in a given gas—say in a vessel full of carbonic acid—the molecules are not all of the same weight. If we compress the gas, we find that when in the state of a perfect gas, or nearly so, the pressure increases just in the ratio that the volume diminishes. That law is entirely explained by means of the molecular theory. It is what ought to exist if the molecular theory is true. If we compress the gas further, we find that the pressure is smaller than it ought to be. This can be explained in two ways: First of all we may suppose that the molecules are so crowded that the time during which they are sufficiently near to attract each other sensibly becomes too large a proportion of the whole time to be neglected; and this will account for the change in the law. There is, however, another explanation. We may suppose, for illustration, that two molecules approach one another, and that the speed at which one is going relatively to the other is very small, and then that they so direct one another that they get caught together, and go on circling, making only one molecule. This, on scientific principles, will account for our fact, that the pressure in a gas which is near a liquid state is too small; that instead of the molecules going about singly, some are hung together in couples and some in larger numbers, and making still larger molecules. This supposition is confirmed very strikingly by the spectroscope. If we take the case of chlorine gas, we find that it changes color—that it gets darker as it approaches the liquid condition. This change of color means that there is a change in the rate of vibration which belongs to its compo-

nent parts; and it is a very simple mechanical deduction that the larger molecules will, as a rule, have a slower rate of vibration than the smaller ones—very much in the same way as a short string gives a higher note than a long one. The color of chlorine changes just in the way we should expect if the molecules, instead of going about separately, were hanging together in couples; and the same thing is true of a great number of the metals. Mr. Lockyer, in his admirable researches, has shown that several of the metals and metalloids have various spectra, according to the temperature and the pressure to which they are exposed; and he has made it exceedingly probable that these various spectra, that is, the rates of vibration of the molecules, depend upon the molecules being actually of different sizes. Dr. Roscoe has, a few months ago, shown an entirely new spectrum of the metal sodium, whereby it appears that this metal exists in a gaseous state in four different degrees of aggregation, as a simple molecule, and as three or four or eight molecules together. Every increase in the complication of the molecules—every extra molecule you hang on to the aggregate that goes about together—will make a difference in the rate of the vibration of that system, and so will make a difference in the color of the substance.

So, then, we have an evidence, you see, of an entirely extraneous character, that in a given gas the actual molecules that exist are not all of the same weight. Any experiment which failed to detect this would fail to detect any smaller difference. And here also we can see a reason why, although a difference in the size of the molecules does exist, yet we do not find that out by sifting. Suppose you take oxygen gas consisting of single molecules and double molecules, and you sift it through a plate; the single molecules get through first, but, when they get through, some of them join themselves together as double molecules; and, although more double molecules are left on the other side, yet some of them separate up and make single molecules; so the process of sifting, which ought to give you single molecules on the one side and double on the other, merely gives you a mixture of single and double on both sides; because the reasons which originally decided that there should be just those two forms are always at work, and continually setting things right.

Now let us take the other point in which molecules are very nearly alike; viz., that they have very nearly the same rate of vibration. The metal sodium in the common salt upon the earth has two rates of vibration; it sounds two notes, as it were, which are very near to each other. They form the well-known double line. The two bright yellow lines are very easy to observe. They occur in the spectra of a great number of stars. They occur in the solar spectrum as dark lines, showing that there is sodium in the outer rim of the sun, which is stopping and shutting off the light of the bright parts behind, and all these lines of sodium are just in the same position in the spectrum,

showing that the rates of vibration of all these molecules of sodium all over the universe, so far as we know, are as near as possible alike. That implies a similarity of molecular structure, which is a great deal more delicate than mere test of weight. You may weigh two fiddles until you are tired, and you will never find out whether they are in tune; the one test is a great deal more delicate than the other. Let us see how delicate this test is. Lord Rayleigh has remarked that there is a natural limit for the precise position of a given line in the spectrum, and for this reason. If a body which is emitting a sound comes toward you, you will find that the pitch of the sound is altered. Suppose that omnibuses run every ten minutes in the streets, and you walk in a direction opposite to that in which they are coming, you will obviously pass more omnibuses in an hour than if you walked in an opposite direction. If a body emitting light is coming toward you, you will find more waves in a certain direction than if it was going from you; consequently, if you are approaching a body emitting light, the light will come quicker, the vibration will be of shorter duration, and the light will be higher up in the spectrum—it will be more blue. If you are going away from the body, then the rate is slower, the light is lower down on the spectrum. By means of variations in the positions of certain known lines of that character, the actual rate of approach of certain fixed stars to the earth has been measured, and the rate of going away of certain other fixed stars has also been measured. Suppose we have a gas which is glowing in a state of incandescence, all the molecules are giving out light at a certain specified rate of vibration; but some of these are coming toward us at a rate much greater than seventeen miles a minute, because the temperature is higher when the gas is glowing, and others are also going away at a much higher rate than that. The consequence is, that instead of having one sharply-defined line on the spectrum, instead of having light of exactly one bright color, we have light which varies between certain limits.

If the actual rate of the vibration of the molecules of the gas were marked down upon the spectrum, we should not get that single bright line there, but we should get a bright band overlapping it on every side. Lord Rayleigh calculated that, in the most favorable circumstances, the breadth of this band would not be less than one-hundredth of the distance between the sodium-lines. It is precisely upon that experiment that the evidence of the exact similarity of molecules rests. We see, therefore, from the nature of the experiment, that we should get exactly the same results if the rate of vibration of all the molecules was not exactly equal, but varied within certain very small limits. If, for example, the rates of vibration varied in the same way as the heads of different men, then we should get very much what we get now from the experiment. From these two sources of evidence, then, the evidence of their being of the same weight and degree of

vibration, all that we can conclude is, that whatever differences there are in their weights, and whatever differences there are in their degrees of vibration, these differences are too small to be found out by our present modes of measurement, and that is precisely all that we can conclude in every similar question of science.

Now, how does this apply to the question whether it is possible for molecules to have been evolved by natural processes? I do not understand, myself, how, even supposing that we knew that they were exactly alike, we could know from that, for certain, that they had not been evolved, because there is only one case of evolution that we know any thing at all about, and that we know very little about yet—that is the evolution of organized beings. The processes by which that evolution takes place are long, cumbrous, and wasteful processes of natural selection and hereditary descent. They are processes which act slowly, which take a great lapse of ages to produce their natural effects. But it seems to me quite possible to conceive, in our entire ignorance of the subject, that there may be other processes of evolution which result in a definite number of forms—those of the chemical elements—just as these processes of the evolution of organized beings have resulted in a greater number of forms. All that we know of the ether shows that its actions are of a rapidity very much exceeding any thing we know of the motions of visible matter. It is a possible thing, for example, that mechanical conditions should exist, according to which all bodies must be made of regular solids, that molecules should all have flat sides, and that these sides should all be of the same shape. I suppose it is just conceivable that it might be impossible for a molecule to exist with two of its faces different. In that case we know there would be just five shapes for a molecule to exist in, and these would be produced by process of evolution. Now, the forms of various matter that we know, and that chemists call elements, seem to be related one to another very much in that sort of way: that is, as if they rose out of mechanical conditions which only rendered it possible for a certain definite number of forms to exist, and which, whenever any molecule deviates slightly from one of these forms, would immediately operate to set it right again. I do not know at all—we have nothing definite to go upon—what the shape of a molecule is, or what is the nature of the vibration it undergoes, or what its condition is compared with the ether; and in our absolute ignorance it would be impossible to make any conception of the mode in which it grew up. When we know as much about the shape of a molecule as we do about the solar system, for example, we may be sure of its mode of evolution as we are of the way in which the solar system came about; but, in our present ignorance, all we have to do is to show that such experiments as we can make do not give us evidence that it is absolutely impossible for molecules of matter to have been evolved out of ether by natural processes.

The evidence which tells us that the molecules of a given substance are alike, is only approximate. The theory leaves room for certain small deviations, and consequently if there are any conditions at work in the nature of the ether, which render it impossible for other forms of matter than those we know of to exist, the great probability is, that when by any process we contrive to sift molecules of one kind from molecules of another, these very conditions at once bring them back and restore to us a mass of gas consisting of molecules, whose average type is a normal one.

Now, I want to consider a speculation of an entirely different character. A remark was made about thirty years ago, by Sir William Thompson, upon the nature of certain problems in the deduction of heat. These problems had been solved by Fourier, many years before, in a beautiful treatise. The theory was, that if you knew the degree of warmth of a body, then you could find what would happen to it afterward, you would find how the body would gradually cool. Suppose you put the end of a poker in the fire and make it red hot, that end is very much hotter than the other end, and if you take it out and let it cool, you will find that heat is traveling from the hot end to the cool end, and the amount of this traveling and the temperature at either end of the poker can be calculated with great accuracy. That comes out of Fourier's theory. Now, suppose you try to go backward, in time, and take the poker at any instant when it is about half cool, and say, "This equation—does it give me the means of finding out what was happening to it before this time, in so far as that state of things has been produced by cooling?" You will find the equation will give you an account of the state of the poker before the time when it came into your hands, with great accuracy up to a certain point, but beyond that point it refuses to give you any more information, and it begins to talk nonsense. It is in the nature of a problem of the conduction of heat, that it allows you to trace the forward history of it to any extent you like; but it will not allow you to trace the history of it backward, beyond a certain point. There is another case in which a similar thing happens. There is an experiment in the excellent manual, "The Boy's Own Book," which tells you that if you put some beer into a glass half full, and put some paper on it, and then pour in water carefully, and draw the paper out without disturbing the two liquids, the water will rest on the beer. The problem, then, is to drink the beer without drinking the water, and it is accomplished by means of a straw. Let us suppose these two resting on each other, we shall find that they begin to mix, and it is possible to write down the equation, which is exactly of the same form as the equation for the conduction of heat, and it would tell you how much water should have gone at any given time after the mixture began. So that, given the water and the beer half mixed, you could trace forward the process of mixing, and measure it with accuracy,

and give a perfect account of it; but if you attempt to trace that back you will have a point where the equation will stop, and will begin to talk nonsense. That is the point where you took away the paper, and allowed the mixing to begin. If we apply that same consideration to the case of the poker, and try to trace back its history, you will find that the point where the equation begins to talk nonsense is the point where you took it out of the fire. The mathematical theory supposes that the process of conduction of heat has gone on in a quiet manner, according to certain defined laws, and that if at any time there was a catastrophe, one not included in the laws of the conduction of heat, then the equation could give you no account of it. There is another thing which is of the same kind. That is the transmission of fluid friction. If you take your tea in your cup, and stir it round with a spoon, it won't go on circulating round forever, but comes to a stop; and the reason is, that there is a certain friction of the liquid against the sides of the cup; and of the different parts of the liquid with one another. Now, the friction of the different parts of a liquid or a gas is precisely a matter of mixing. The particles which are going fast, and are in the middle, not having been stopped by the side, get mixed, and the particles at the side going slow, get mixed with the particles in the middle. This process of mixing can be calculated, and it leads to an equation of exactly the same sort as that which applies to the conduction of heat. We have, therefore, in these problems, a natural process which consists in mixing things together, and this always has the property that you can go on mixing them forever, without coming to any thing impossible; but if you attempt to trace the history of the thing backward, you must always come to a state which could not have been produced by mixing, namely, a state of complete separation.

Now, upon this remark of Sir W. Thompson's, which you will find further expressed in Mr. Balfour Stewart's book on the "Conservation of Energy," a most singular doctrine has been founded. These writers have been speaking of a particular problem, on which they were employed at the moment. Sir W. Thompson was speaking of the deduction of heat, and he said this heat-problem leads you back to a state which could not have been produced by the conduction of heat. And so Prof. Clerk Maxwell, speaking of the same problem, and also of the diffusion of gases, said there was evidence of a limit in past time to the existing order of things, when something else than mixing took place. But a most eminent man, who has done a great deal of service to mankind, Prof. Stanley Jevons, in his very admirable book, "The Principles of Science," which is simply marvellous for the number of examples illustrating logical principles which he has drawn from all kinds of regions of science, and for the small number of mistakes that occur in it, takes this remark of Sir W. Thompson's, and takes out two very important words, and puts in two other very

important words. He says, "We have here evidence of a limit of a state of things which could not have been produced by the previous state of things according to the known laws of Nature." It is not according to the known laws of Nature, it is according to the known laws of conduction of heat, that Sir William Thompson is speaking; and that mistake illustrates the fallacy of concluding that, if we consider the case of the whole universe, we should be able, suppose we had paper and ink enough, to write down an equation which would enable us to make out the history of the world forward, as far forward as we liked to go, but if we attempted to calculate the history of the world backward, we should come to a point where the equation would begin to talk nonsense, we should come to a state of things which could not have been produced from any previous state of things, by any known natural laws. You will see at once that that is an entirely different statement. The same doctrine has been used by Mr. Murphy, in a very able book, "The Scientific Bases of Faith," to build upon it an enormous superstructure. I think the restoration of the Irish Church was one of the results of it, but this doctrine is founded, as I think, upon a pure misconception. It is founded entirely upon forgetfulness of the condition under which the remark was originally made. All these physical writers, knowing what they were writing about, simply drew such conclusions from the facts which were before them as could be reasonably drawn. They say, "Here is a state of things which could not have been produced by the circumstances we are at present investigating." Then your speculator comes, he reads a sentence and says, "Here is an opportunity for me to have my fling." And he has his fling and makes a purely baseless theory about the necessary origin of the present order of Nature at some definite point of time which might be calculated. But, if we consider the matter, we shall see that this is not in any way a consequence of the theory of the deduction of heat. If we apply that to the case of the earth, we find that at present there is a certain distribution of temperature in the interior of it, there is a law according to which the temperature increases as we go down, and no doubt if we made further investigations, we should find that if we went deeper an accurate law would be found, according to which the temperature increases as we go downward.

Now, assuming this to be so, taking this as the basis of our problem, we might endeavor to find out what was the history of the earth in past times, and when it began cooling down. That is exactly what Sir William Thompson has done. When we attempt it, we find that there is a definite point to which we can go, and at which our equation talks nonsense. But we do not conclude that at that point the laws of Nature began to be what they are; that is the point where the earth began to solidify; that is a process which is not a process of the deduction of heat, and so the thing cannot be given by the

equation. Now, that point is given definitely as a point of time, not with great accuracy, but still as near as we can expect to get it, with such means of measuring as we have, and Sir William Thompson has calculated that the earth must have solidified at some time a hundred millions or two hundred millions of years ago; and there we arrive by a present state of things at the beginning of the process of cooling the earth which is going on now. Before that it was cooling as a liquid, and in passing from the liquid to the solid state there was a catastrophe which introduced a new rate of cooling, so that by means of that law we do come to a time when the earth began to assume the present state of things—not that of the existence of the universe at all; we do not give the time of the commencement of the universe, but simply the structure of the earth. If we went farther back, we might make a further calculation and find how long the earth had been in a liquid state. We should come to another catastrophe, and say at that time, not that the universe began to exist, but that the present earth passed from the gaseous to the liquid state. And if we went farther back still we should probably find the earth falling together out of a great ring of matter surrounding the sun, and distributed over its orbit. The same thing is true of every body of matter: if we trace its history back, we come to a certain time at which the catastrophe took place, and if we were to trace back the history of all the bodies of the universe in that way we should continually see them separating up, and falling together, as they have done. What they have actually done is to fall together and get solid. If we should reverse the process we should see them separating and getting cool, and, as a limit to that, we should find that all these bodies would be resolved into molecules, and all these would be flying away from each other. There would be no limit to that process, and we could trace it as far back as ever we liked to trace it. So that on the assumption, a very large assumption, that the present constitution of the laws of geometry and mechanics has held good during the whole of past times, we should be led to the conclusion that at an inconceivably long time ago the universe did consist of ultimate molecules, all separate from one another, and approaching one another, because we have to reverse our former process. Instead of their being at a great distance from one another, and all traveling toward some place where they would meet, the reverse would be the case. Then you would have the process of chlorine going on in these bodies, exactly as we find it going on now, but you will observe that we do not come to such a catastrophe as implies that we have to stop these laws of Nature. We come to something of which we cannot make any further calculation; we find that, however far we like to go back, we approximate to that actual state of things, but never actually get to it. Here we have a doctrine about the beginning of things. First, we have a probability, abourt as correct as science can make it, of the

beginning of the present state of things on the earth, of the fitness of the earth for habitation; and then we have a probability which is an exceedingly small one, which is certainly put in this form, that we do not know any thing at all about the beginning of the universe as a whole.

The reason why I say that we do not know any thing at all of the beginning of the universe is, that we have no reason whatever for believing that what we at present know of the laws of geometry are exactly and absolutely true at present, or that they have been even approximately true for any period of time, further than we have direct evidence of. The evidence we have of them is founded on experience, and we should have exactly the same experience of them now, if those laws were not exactly and absolutely true, but were only so nearly true that we could not observe the difference, so that in making that assumption, that we may argue upon the absolute uniformity of Nature, and supposing them to have remained exactly as they are, we are assuming something we know nothing about. My conclusion then, is, that we do know, with great probability, of the beginning of the habitability of the earth about one hundred or two hundred millions of years back, but that of the beginning of the universe we know nothing at all.

Now, let us consider what we can find out about the end of things. The life which exists upon the earth is made by the sun's action, and it depends upon the sun for its continuance. We know that the sun is wearing out, that it is cooling, and although this heat which it loses day by day is made up in some measure, perhaps completely, at present, by the contraction of its mass, yet that process cannot go on forever. There is only a certain amount of energy in the present constitution of the sun, and, when that has been used up, the sun cannot go on giving out any more heat. Supposing, therefore, the earth remains in her present orbit about the sun, seeing that the sun must be cooled down at some time, we shall all be frozen out. On the other hand, we have no reason to believe that the orbit of the earth about the sun is an absolutely stable thing. It has been maintained for a long time that there is a certain resisting medium which the planets have to move through, and it may be argued from that, that in time all the planets must be gradually made to move slower in their orbits, and so to fall in toward the sun. But, on the other hand, the evidences upon which this assertion was based, the movement of Encke's comet and others, has been quite recently entirely overturned by Prof. Tait. He supposes that these comets consist of bodies of meteors. Now, it was proved, a long time ago, that a mass of small bodies traveling together in an orbit about a central body will always tend to fall in toward it, and that is the case with the rings of Saturn. So that, in fact, the movement of Encke's comet is entirely accounted for on the supposition that it is a swarm of meteors, without regarding

the assumption of a resisting medium. On the other hand, it seems exceedingly natural to suppose that some matter in a very thin state is diffused about the planetary spaces. Then we have another consideration: just as the sun and moon make tides upon the sea, so the planets make tides upon the sun. If we consider the tide which the earth makes upon the sun, instead of being a great wave lifting the mass of the sun up directly under the earth, it lags behind, the result is that the earth, instead of being attracted to the sun's centre, is attracted to a point behind the centre. That retards the earth's motion, and the effect of this upon the planet is to make its orbit larger. That planet disturbing all the other planets, the consequence is, that we have the earth gradually going away from the sun, instead of falling into it.

In any case, all we know is that the sun is going out. If we fall into the sun then we shall be fried; if we go away from the sun, or the sun goes out, then we shall be frozen. So that, so far as the earth is concerned, we have no means of determining what will be the character of the end, but we know that one of these two things must take place in time. But in regard to the whole universe, if we were to travel forward as we have traveled backward in time, consider things as falling together, we should come finally to a great central mass, all in one piece, which would send out waves of heat through a perfectly empty ether, and gradually cool itself down. As this mass got cool it would be deprived of all life or motion; it would be just a mere enormous frozen block in the middle of the ether. But that conclusion, which is like the one that we discussed about the beginning of the world, is one which we have no right whatever to rest upon. It depends upon the same assumption that the laws of geometry and mechanics are exactly and absolutely true, and that they have continued exactly and absolutely true for ever and ever. Such an assumption we have no right whatever to make. We may therefore, I think, conclude about the end of things that, so far as the earth is concerned, an end of life upon it is as probable as science can make any thing, but that in regard to the universe we have no right to draw any conclusion at all. So far we have considered simply the material existence of the earth; but of course our greatest interest lies not so much with the material things upon it, its organized things, as with another fact which goes along with that, and which is an entirely different one—the fact of the consciousness that exists upon the earth. We find very good reason indeed to believe that this consciousness in the case of any organism is itself a very complex thing, and that it corresponds part for part to the action of the nervous system, and more particularly of the brain of that organized thing. There are some whom such evidence has led to the conclusion that the destruction which we have seen reason to think probable of all organized beings upon the earth will lead also to the final destruction of the conscious-

ness that goes with them. Upon this point I know there is great difference of opinion among those who have a right to speak. But, to those who do see the cogency of the evidences of modern physiology and modern psychology in this direction, it is a very serious thing to consider that not only the earth itself and all that beautiful face of Nature we see, but also the living things upon it, and all the consciousness of men, and the ideas of society, which have grown up upon the surface, must come to an end. We who hold that belief must just face the fact and make the best of it; and I think we are helped in this by the words of that Jew philosopher who was himself a worthy crown to the splendid achievements of his race in the cause of progress during the middle ages, Benedict Spinoza. He said, "The freeman thinks of nothing so little as of death, and his contemplation is not of death but of life." Our interest, it seems to me, lies with so much of the past as may serve to guide our actions in the present, and to intensify our pious allegiance to the fathers who have gone before us, and the brethren who are with us; and our interest lies with so much of the future as we may hope will be appreciably affected by our good actions now. Beyond that, as it seems to me, we do not know, and we ought not to care. Do I seem to say, "Let us eat and drink, for to-morrow we die?" Far from it; on the contrary, I say, "Let us take hands and help, for this day we are alive together."—*Fortnightly Review.*

# SEXUAL CEREBRATION.

BY ELY VAN DE WARKER, M. D.

BY sexual cerebration is meant the existence of sex in the emotional and ideo-motor psychical nature of women and men, from which originate *per se* emotions and states of consciousness which distinguish and give character to the intellection of the sexes. It is sex in mental, as distinguished from sex in physical development. It is to mental operations what the prism is to light—a medium of refraction; a bending, as it were, of the axis of thought.

Having postulated that certain differences exist mentally between the sexes, is it possible to determine the extent and nature of the difference? Is it also possible to trace this difference to a sexual factor? It is evident that, if we can reach the truth, approximately, in the first question, the establishment of the second is easy.

There appears to me but one way of studying this question. The old speculative method of investigating metaphysical questions must be abandoned. We must grapple with this psychological problem from a few fixed points; like points of triangulation, to measure distances which otherwise may remain unknown. We must reason from

the known to the unknown. These fixed points are to be found in anatomy and physiology. We may also study certain voluntary acts of the sexes in the aggregate, and estimate the difference in the result. The relations between the sexes will also furnish facts from which mental differences may be estimated.

Accepting Dr. Carpenter as the exponent of thought upon the physiology of mental action, we shall give his estimate of the cerebrum, or "brain," as "ministering, so far as any material instrument may do, to the exercise of these psychical powers which, in man, exhibit so remarkable a predominance over the mere animal instincts." The brain, anatomically, may be classed among the ganglia, having its function more clearly defined than is usual with great nerve-centres. It is not an assumption, then, which will provoke dissent among modern physiologists, to assume the brain as the "organ of thought;" not in the sense that it secretes thought, but that it presides in its own way over its special function, that of intellection. It is the operation of the brain in its functional capacity which gives to each individual his mental peculiarities. These differences in mental action which define the individual must represent differences in functional activity. Taking this view of the physiology of thought, it is just to say that this exhibit of mental differences is the measure of functional, if not of structural, peculiarities, in the great brain-ganglion. If this is true of several individuals, it must also be true of the sexes. The mental traits, which define the sexes intellectually, afford a measure of either functional or structural differences in the cerebral ganglion. It is very possible that, histologically, any structural differences which may exist in the ganglia of either individuals or the sexes may never be determined. But the drift of modern thought and research tends to show that such differences do exist, and it is as true approximately as the undulatory theory of light. Many of the functional attributes of sex are presided over by ganglia having special reference to these functions, and these groups of nerve-centres in the sexes, one being the analogue of the other anatomically, must differ widely in function, notwithstanding their similarity of location and structure. When we take into consideration that the forces of organic and functional life represent simply the sum of ganglionic activity, a just idea may be formed of the extent to which this activity must be differentiated in the sexes. It is simply necessary to extend the field of ganglionic action to the brain, the supreme ganglion of all, in order to realize the fact that here also functional differences must exist. That the brain possesses functions in common to the sexes in no wise renders it impossible to perform its part as an organ embraced in the sexual cycle. The relations existing between the sexes are mutually voluntary, and involve more or less of mental action. As these relations represent the opposite poles of structural and functional life, this mutuality must also represent phases of mental action which exist as sexual traits.

Concerning many of these relations we know that men and women do not think alike, and that these differences are radical ones, and have existed many years, and yet continue to exist. Take the labor and the ballot questions as the most widely known of the points of disagreement, which seem to have their origin in sexual mental attributes. But, even upon these questions, we find many men and women thinking and acting alike. Yet these are the exception, and not the rule; which confirms my idea of the difference in the results reached by the mental processes of the sexes: for surely the want of agreement must be a radical one in which it is a rare exception for the two types of mind to approach each other upon matters other than the organic emotions. Keeping in view the accepted fact that the brain, as an organ, or nerve-centre, is the seat of mental action, with which its structure, either in its histological elements or its relative proportion of parts, is more or less intimately connected, it seems reasonable to refer these differences in the results of sexual mental processes to structural rather than to any ephemeral cause. If we estimate the sexual factor in brain-development by the aggregate of results attained by the sexes, the way is clearer. The known average excess in weight in the male brain is the most probable coefficient of this excess in results. The face of Nature has fairly been changed by man's labor. The vast systems of railroads, of canals, of mountains pierced by tunnels, of lines of telegraph and cables, the steamships, the vast engines of war, the great emporiums of commerce, the results reached by masterly labors in science which underlie all these grand results, and in which women have been the accessories rather than the collaborators, prove that some factor, other than superior strength of bone and muscle, has led to this vast excess in results reached by man. These results represent brain-labor; and to what cause can we assign it, if not to this great development of the brain of man over that of woman?

In the organic emotions, and in the play of those finer feelings which form distinguishing mental traits of the sexes, we have the same reason to seek for a physical basis. As these mental traits are analyzed in the course of the paper, it will become more evident that the brain in the sexes is an organ embraced structurally in the sexual cycle. With this sexual factor existing in brain-structure, can woman ever hope, in entering the field of man's labor, to do his work in man's way? Will she write sermons, draw up a brief, or treat disease with the same facts before her, in the way of man? I do not believe I show disrespect to the sex when I answer, No. Women in literature have occupied a distinctive place. A book or an article in which the sex of the writer cannot be detected, no matter how studiously concealed, forms an event in literature. When woman labors either with her hands or head, notwithstanding she reaches the same result as man, she labors in her own way. All this, I believe, points not so

much to a womanly habit, as to a womanly brain as well as body. Sex is a law to body as well as brain. Sex pervades all Nature, not for the sake of the individual, but for that of the species.

In the insect-world, some bright little creature lives but a few hours, deposits its egg and dies. The sum of its life is sex. Not less do I believe does man, notwithstanding the grandeur of his intellect, conform to the same inexorable law.

Before we enter upon the more difficult part of our subject, there are certain conceded mental attributes peculiar to the sexes which are legitimate subjects of investigation. I say there are mental differences conceded; because, without thought, we include them in our ideal of women, or of men. In the same manner, we need not recall to our minds, or to the minds of others, that women are characterized nearly the world over by peculiarities of dress which distinguish them as a sex. It is part of our ideal of women, because they have ever been associated with such peculiarities. In literature and art, woman has maintained her lofty place, separated more widely from man by her mental trait than by her differences in form. It has ever been a theme more of mind than of matter which has inspired the poet to entwine women in his graceful verse. Her truth, her gentleness, her constancy, these are immortal themes; these are the chords of her nature which have found responsive vibrations in the hearts of poets, and made the monuments of their genius eternal. When the poet and the artist see more in the enticements of woman's form than in her mind, the best of men shrink from the picture. Is it not because our ideal woman in art is associated more with sexual graces of mind than of body? When that strange poet, Algernon Swinburne, clothed in his matchless English the gospel of the flesh, the world of literature recoiled. This union of the gentle nature of woman as a theme with the beautiful in literature, dates back to the cradle of art. Now, what are these conceded mental differences between the sexes.—"Soothing, unspeakable charm of gentle womanhood! which supersedes all acquisitions, all accomplishments," says George Eliot, in "Scenes of Clerical Life."

We may assume gentleness of mind as a sexual mental trait. It does not spring from any process of conscious reasoning. It has no main-spring in a sense of expediency. Unconsciousness and spontaneity are the conditions of its existence. The practical bearing of this paper is to estimate the value of these mental traits as affecting the affairs of daily life. Necessarily, therefore, we must have an approximate standard of measurement. I seek this standard in that class which usually deals with the active affairs of life—the masculine type of mind. Not only for this reason do I select this criterion; but, also, this is the type women are endeavoring to reach in essaying a career in the professions. The two types of mind, masculine and feminine, by mutual contrast afford the surest indication of sexual

differences in intellection. This gentleness of woman has found its way into the argument as something definite, as a descriptive trait of character, yet by itself is nameless. Relating to woman as it chiefly does, it seems to consist of a mobility and pliability of character, an unconscious avoidance of harshness and fixity of thought. Not a want of fixity as indicating fickleness of character, but implying concessions to the wishes of others. This gentleness of mental habitude in women, which so clearly isolates the psychical condition of the sexes, finds its factor in sexual differences. Unavoidably, this takes approximate force. Reasoning cannot make it clearer that this type of woman is an expression of sex in mind. We see this feminine type of mind associated with certain bodily configurations which are equally expressive of sex. We also find exceptions to this form of sexual cerebration. There are women who approach more or less nearly in positiveness and habitual harshness to the masculine type. With this there is almost invariably associated masculine development of form. Masculine brawn, bone and muscle, shaded and toned down by the irrepressible presence of sex, define this phase of the feminine mind. The voice approaches a manly compass, the down upon the upper lip becomes short, delicate hairs; the stature exceeds the average of woman's; the limbs are muscular and strong. With these bodily powers of aggression there is a natural outgrowth of mental belligerence. This is a law of Nature. The man who shrinks from a physical contest with his fellows is one of conscious bodily weakness. His body measures, therefore, the extent of mental aggressiveness. Not necessarily do these women possess the male intellect; they simply approach the male type in this single aspect of their characters, other and equally feminine attributes of mind existing in full force. But, as demonstrating a sexual origin for this traditional and actual gentleness of the female mind, the fact that certain departures from the typical feminine form are associated with equally positive analogies to the typical masculine mind, seems to me to be conclusive.

These two conditions of mind existing in full force tend to place the sexes at the opposite poles of human actions, that of demanding and yielding, that of giving and receiving. George Eliot is right in saying that this feature of mental character supersedes all acquisitions, all artificial acquirements. Education and refinement may lend it additional attractiveness, but it is a primordial sexual trait of mind—the brightest gem in woman's chaplet of mental charms, around which may cluster other and equally attractive traits without impairing its lustre.

I believe it to be evident that the opposite psychical conditions of the sexes under consideration determine for men and women their careers in society—to one the strife and struggle with the world, to the other the gentle occupations of the home. From the male sex we may obtain a forcible example of how potent is the sexual factor in

shaping the mental character of the sexes. Men reduced to a condition of eunuchism afford a wonderful contrast to men in the normal condition. It is upon the cerebrum and on its function of cerebration that some of its most marked effects are to be observed. He ceases to be fit for war, and is of service only in the pursuits of peace. He is no longer capable of daring to assert his rights, and, of all beings, is a fit subject for a slave. Not only is he made a coward, but the moral senses are weakened, and he may be safely delegated to execute the cruelty of others. It does not seem, then, to be any thing but a legitimate deduction that this radical difference, intellectually, between the normal man and eunuchism is the participation of the brain in the generic cycle, and one phase of sexual cerebration.

Through all the females of the mammalia, there exists a feeling toward their young called the *maternal instinct*. There is no necessity here of going into the question of instinct among animals, as to whether it partakes of the nature of an intellectual process. Whatever be its nature, it is evidently a part of generation, and as such is eminently sexual in its origin. In dealing with this feeling in the human female, although it may have a rudimentary intellectual source, yet it is lifted above the level of instinctive feeling, and becomes a part of her emotional nature. "The intimate and essential relation of emotions to the ideas, which they equal in number and variety, is sufficient to prove that the law of progress from the general and simple to the special and complex prevails in their development" (Maudsley). Thus it is that an instinctive feeling in lower animals, without which the reproductive faculty would be totally defeated, becomes the maternal emotion in its simplest form in the human being; and, by carrying on this evolution from the simple to the complex, produces a complete modification of the psychical tone. Here, also, we may gain a clearer insight into the nature of the maternal feeling by contrasting it with the paternal feeling.[1] This emotion is a state of the mind which obtains the conditions of its existence from the same physical faculty—that of reproduction; and although it is closely related to the expression of the maternal feeling in the more developed state of the emotion, yet, in its fundamental form, it differs widely.

Thus, among the male of the mammalia in which it is not entirely absent, it mostly assumes the form of abstaining from injury, while in the female of the same species it exists as a protecting and maintaining instinct.

In the human race, the same emotion receives a shadow cast from its primal origin in animals. In the human female, in the child-bearing period, it exists as a love, active or passive, for all children; while in men, during the more active period of manhood, it exists as a gentle tolerance of children, until called out in its active form by his own

[1] The word "feeling" is here used, not in its idiomatic sense, but as a state of consciousness.

paternity. Notice from this that even the lofty elevation of intellectual man, and exalted yet higher by the force of education, has not been sufficient to change beyond recognition this emotion in its relative condition and quality as it exists among animals.

We cannot separate the mental from the bodily life. When we scan the deeper relation of things in their genesis, there are displayed in closest connection continuity of parts and functions (Maudsley). The maternal emotion exists potentially in the intellection of the healthy adult woman as a natural outcome of the existence of organs and functions which render possible the occasion of its activity. As the time approaches for its full development, any observing physician can perceive the latent emotion assuming shape and direction to a definite end. Numberless cares and solicitudes, colored by the tenderest of anticipations, become dominant in her volition. Not once, but innumerably, has a star over Bethlehem shed its lucid light in the hearts of watchers, and roused from the depths of latent emotions, half stifled with agony, the infinite possibilities of a mother's love. De Quincey, who intellectually stood so near the verge of the impossible in thought, and measured the heights and fathomed the depths of hearts, looked upon this kindling of the maternal emotion, at the supremest moment of a woman's life, with the eyes of a seer. Until I read this,[1] there always seemed an incongruity in the piercing grief of a mother over the death of her new-born. One with whom there was associated not a single earthly emotion, save that of maternity, but who was freshly linked with a hundred pangs, received upon its little, scarcely human face, the most keenly-felt of maternal tears. The reason is plain. The emotion of maternity exceeds reason, transcends imagination, and is brought forth from the depths of organic life as part of the mystery of reproduction. As from the state of eunuchism we gained a knowledge of the sexual origin of certain attributes which distinguish man intellectually, so, from the condition resulting after the operation of spaying in animals, we may obtain additional evidence of the origin of the maternal feeling. Animals so treated have a great aversion for the young of their own species; that which was the maternal instinct in the normal animal becomes an instinctive hatred in the unsexed one. Here it is evident that the presence of organs whose existence is necessary to the completion of function is a prime factor in the creation of an overruling instinct. I have already drawn attention to the great resemblance between the maternal emotion in human beings and the maternal instinct in animals, and it does not seem to be unreasonable to trace both emotion and instinct to a common and physical cause. It is not in the power of a woman, normal psychically and physically, to repress her maternal emotion in the presence of her new-born, and in this respect she is allied to her sister animals. But the analogy here ceases. The

[1] "Suspiria de Profundis."

woman is gifted with intellect, the animal is not; the woman has memory, the animal has none; and thus it is that the maternal instinct ceases with the necessity of providing food for the young; the maternal emotion in the human mother ends only with her life. But yet again, how tender is the mother with her new-born babe, compared to the exhibition of the same emotion toward her half-grown child!

The differentia that exist between the maternal and paternal emotions are such as characterize other expressions of sexual cerebration. I have already called attention to some of them. Among men, as the mind assumes its higher moral and intellectual development, these emotions are more nearly alike in the sexes, so far as constancy and care are concerned. If we take into consideration the frequency of the charge against men of desertion of family and children, and the extreme rarity of this charge against woman, we perceive that the paternal emotion must be accompanied by a certain degree of moral sense in order to equal the maternal emotion, which alone, and unaided by any mental accessory, is, as a rule, capable of the most heroic sacrifice. I think I may end our study of the maternal emotion here, with no doubt in my mind, and with but little chance of valid objections on the part of others, that it is purely the result of sexual organization; that not indirectly, but directly, it is the psychical component of the reproductive faculty, and as such is notably an example of sexual cerebration.

*Love* is the attraction between the sexes. The word is wrongly used to express a great variety of relations and emotions. Spinoza says that, "between appetite and desire there is no difference, except so far as the latter implies consciousness; desire is self-conscious appetite." It is important that the presence of consciousness be not allowed to obscure the fundamental condition of things in the brain. Because of the affinity between vital structure and instinct or impulse, the organic reaction becomes evident as a condition of consciousness, overlooking the primary cause. "The striving after a pleasing impression, or the effort to avoid a painful one, is at bottom a physical consequence of the nature of the ganglionic cell in its relation to a certain stimulus; and the reaction or desire becomes the motive of a general action on the part of the individual, for the purpose of satisfying a want or of shunning an ill" (Maudsley). Any of these self-conscious appetites may become the main-spring of a voluntary action. A desire which so results is gradually evolved out of an unconscious organic appetite into an emotion, or a series of intelligently-connected efforts. The physiological relation existing between the sexes is a part of the organic law of reproduction. The action of this law finds its expression through the brain, instinctively or emotionally in desire. This participation of the brain in the reproductive stimulus is an absolute necessity in order to place the sexes in a relation favorable to an observance of one of the laws of their existence. With the gradual

evolution of sex physically there is a corresponding evolution psychically. The one is necessary to the organic part, the other is necessary to the mental part, of reproduction. This development of the possibility of love with structural completion is one of the most striking examples of the evolution of organic life into consciousness. The mental awakening is gradual. Vague and undefined desires exist long before they have taken definite shape in the consciousness; there is a satisfaction, too obscure and gradually evolved to startle the subject into consciousness, in the society of the other sex. These undefined desires become a part of a self-conscious act when one object is selected from the many and is associated with the most sacred emotion—love. In order to prove that this emotion can exist independent of consciousness, and antedate it as it were, it is only necessary to allude to the fact that, in human beings, the instinct attains a knowledge of its aim, and even a sort of satisfaction, in dreams, before it does so in real life. Upon this Dr. Maudsley remarks as follows: "This fact might of itself suffice to teach psychologists how far more fundamental than any conscious mental state is the unconscious mental or cerebral life."

Physiologically, this is the origin of the beautiful emotion called love. In a healthy brain and body, one in which all organic impulses find a reaction in normal consciousness, the emotion of love is allied with all that is pure and noble in the character of the individual. Men find in it an incentive to exertion, and a spur to their ambitions, while women without thought array themselves in all the graces of dress and manner to attract the beloved one. But we can say of love, what Bacon says of it, that "the mind in its own nature would be temperate and staid, if the affections, as winds, did not put it in tumult and perturbation." This may be the effect of love even in its healthy manifestations. In those cases—and they are not rare—in which the organic appetites affect unduly and too persistently the consciousness, it becomes the source of great unhappiness or of bad health. It would be indeed hard to recognize as love the exhibition of this emotion in the depraved. Among this class it is exhibited as love brutalized. Revolting as it is in this form to all that is elevated in our mental character, I yet believe it to be love in its rudimentary form. It is love stripped of its refinements, of its singleness of object, of its purity. It is often said that man is but little lower than the angels; if there is any thing which tends to this imaginary elevation it is this faculty of identifying another with all earthly hopes, of making the happiness and well-being of a fellow-creature the aim and motive of a lifetime. But this same emotion, when it finds expression in these abnormal states of consciousness, allies man to the brute, and tends to show from what depths the present moral and intellectual nature of man was elevated by the slow progress of evolution.

As I have already tried to show that mentally men and women define two opposite types of mind, we shall find strong confirmation

of this by contrasting love as presented in the sexes. As there is no process of vivisection or array of physical facts which will prove this, we must study this emotion as we know it to exist in the mass of men and women, and which has been verified by common experience. But, in the first place, we must bear in mind the widely-diverging paths in life followed by men and women. Men enter the world and labor bodily or mentally, and thus expend all surplus energy. This energy is used at the direct expense of the emotional life. Women, as a rule, do not have this vicarious outlet for the emotions. Love with women exists as an entity, with men as an abstraction. A study of tables of suicidal deaths in both sexes gives us some startling evidence of the difference in both the intensity and effect of this emotion in men and women. The decade between twenty-five and thirty-five years of age affords the largest number of voluntary deaths for women. It is during this period of woman's life that the demand for love is greatest. The functional life is exerting its most potent sway over mind and body. Thus it is that to love and to be loved is a physiological demand during this period, and it becomes evident that this excess of suicides is the outcome partly of a defeated sexual life. The figures for men present a remarkable contrast. The same period in the life of men is also the period of greatest sexual activity. But, whatever vicissitudes the emotion of love among men may be subjected to, it does not find expression in self-destruction. On the contrary, the period of greatest liability to suicides is postponed to the period when the sexual energies have expended their youthful ardor, so that the decade between thirty-five and forty-five years of age gives the greatest number of suicidal deaths, and during which interval it is that the business or worldly interest of men attains success, or ends in failure.

Another fact derived from the same source throws light on this interesting subject. The condition of concubinage almost trebles the number of voluntary deaths for women. It seems reasonable, from what we know of human beings, to assert that it is not the continuance, but the breaking up of these relations—which, in a monogamous state of society, must invariably occur—that leads to this result. We have here almost positive proof that this tendency to self-destruction in the relation of women to the other sex finds its factor in a defeated sexual feeling or love. It is generally understood that the mental and bodily structure and function of women develop at an earlier age than in the other sex. Now, there are twice as many suicides among girls as among boys under the fifteenth year. A leading character of the earlier development of women over the other sex is a sexual one—a capacity to love and to be loved. It is a very significant fact in comparing the degree and quality of love as we find it existing in men and women, that the two periods in woman's life in which suicidal deaths exceed those in the male are at the time of structural completion and greatest functional activity. This demonstrates the predominance of

a capacity to love in woman's psychical nature, and its greater power to impress itself profoundly upon the deliberate acts of her life over that of man. Madame de Staël truly said that "love is the history of woman's life; it is an episode in man's."

Love defeated in the attainment of its object becomes in man an incident to be forgotten, or to be remembered with impatience. A defeated love with woman is too often a defeat of her intellectual life. An emotion, the misdirection or disappointment of which is capable of inducing a large per centum of insane in one sex over the other, must surely differ in degree and kind. Certainly we must credit this excess on the part of women with an important physical factor, aside from that of sex proper—being of a less hardy development than man—but these physical peculiarities permit sex to assert its most potent psychical effect to the degree of shaping the actions or destiny of woman. It will suffice, to illustrate the fact referred to, to take the figures from the report of two asylums for the insane—the Pennsylvania Hospital for the Insane, and the Michigan Asylum. Of 141 insane men and women received into these institutions, whose supposed cause of insanity could be traced to disappointed affections, 84 were women, and 57 were men. These figures are taken from an excess of 454 male over female inmates. Now, the figures, as we gather them from asylum reports, show that women are no more prone to insanity than men. It is natural to conclude that a specific cause leading to this excess of insanity in one sex over the other exists with greater force in one than the other, and not that one sex is less able to bear the operation of the specific cause.

There are many well-known facts in physiology, some of them brought out with remarkable force during the employment of anæsthetics, other facts obtained from a state of organic disease, and others from functional derangements, which tend to prove the sexual origin of love, but which would be out of place in a paper of this character. But there is really no doubt expressed by modern writers on physiology or psychology that this emotion is due to a sexual origin. Proof, such as I have advanced, becomes necessary from the popular scope of this paper, and that I have grouped a series of mental acts, and applied to them the name of sexual cerebration.

I offer, in conclusion, some general facts tending to define a fundamental difference in the mental operations of men and women. M. Quetelet has shown that the propensity to crime existing in a mass of people bears a mathematical ratio, both as to its degree and the sex of the perpetrators, to the total of population year by year. The certainty of this ratio is the result of law, which has its origin in the forces which cement together a mass of men under the name of society. Now, the fixed ratio existing between men and women of the same community, as to the nature and extent of the commission of crime, must be the product of the mental and physical peculiarities of sex.

Thus, the author shows that the propensity to crime in men is about four times as great as in women, in France. Now, while this holds true as to crime in general, it does not as to crime in particular. In poisoning, the proportion is 91 women to 100 men, while in murder by other means the difference falls to 4 in 100. If we define the propensity to crime by the enormity of the offense, we find the ratio of M. Quetelet reduced just one-half, as the crime of parricide gives the ratio of 50 to 100. Contrasting with this last offense the wounding of parents, the ratio falls to 22. As the fact of a wound involves the necessity of a personal encounter, we perceive that women instinctively—if I may use the word—shrink from this; therefore, in estimating the means by which the parricides, so greatly exceeding the ratio of other murders, were accomplished, it is evident that some method peculiar to women entered largely into the crime. Next, taking into consideration two crimes, which may, inferentially, be attributed largely to the motive of revenge in both sexes, we find for that of incendiarism a ratio of 34, and for that of assassination a ratio of but 12 in 100. From this it is evident that the propensity to crime and the degree to which women recoil from publicity in its execution are widely different matters, and are traits which distinguish women from men in the perpetration of crime. So marked is this trait that the author, in analyzing crime in general with reference to sex, says that "their numbers diminish in proportion according to the necessity of the greater publicity before the crime can be perpetrated." There are other facts to be reached in this direction showing the extent to which women's criminal acts are affected by sexual peculiarities. In the two great divisions of crime, that against persons and that against property, we find that the sexes are engaged in almost a constant ratio. This is fixed for a series of years for the first class of crimes as 0.16, and for the second at 0.26. In connection with this is a fact, which reiterates itself with the force of a law. It is found that the proportions of the sexes engaged in the crimes against persons and property represent very nearly the same ratio as that of the strength of the two sexes, 16 to 26. The law which controls the commission of crime by the sexes evidently cannot be reduced to the formula of a difference in the propensity to crime dependent upon the relative morality of men and women, but is governed by mental and physical sexual peculiarities. All these figures relate to four years previous to 1830.[1]

The application of this to the matter under investigation is evident. These various actions, involving more or less of thought and resolve, exhibit a radical difference, both in degree and quality, which must have their factors in mental peculiarities. It cannot be objected that there is simply a fundamental physical basis for this difference, since the mental differences of sex must have their origin in the physi-

[1] "A Treatise on Man," pp. 90–92.

cal differences which constitute sex. The fact that the ratio of the extent to which women perpetrate crimes against property is to crimes against persons the same as the ratio of strength between men and women, proves that her less degree of physical power, which is a sexual property, so affects mental action that her deliberate acts are capable of tabulation, and, contrasted with those of men, show a constant series of differences year by year. Were it otherwise, we would expect that these uniform ratios, which point so unerringly to the workings of a law, would disappear, and in their place we should have tabulated confusion.

We obtained an idea of love differentially as it exists in the sexes by observing the degree to which it affects men and women as a probable cause of insanity. In the same manner I think we can gain a knowledge of the comparative intensity with which emotions and states of consciousness, common to both sexes, exist in intellection, by observing the extent to which they react as a probable cause of mental alienation. For my purpose I shall use Dr. Kirkbride's report for the Pennsylvania Hospital for the Insane. The analysis is based upon the supposed causes of insanity in 6,899 cases. Domestic difficulties are the probable causes of mental disease in 47 men and 86 women. Nearly two to one expresses the difference in intensity in the action of this cause. Fright resulted in insanity in 16 men and 36 women. Grief affected 77 men and 256 women, a difference of more than three to one. Religious excitement acts as the cause in 79 men and 127 women, a difference of sixty-two per cent. Nostalgia, 7 women, and no men. From mental anxiety there are 164 men and 261 women insane. These causes, which present such dissimilarity, have one bond of union; they affect the emotional part of the psychical nature. From this I would not conclude that women are less able to bear the operation of these exciting causes than men; but, that the emotional nature of woman is more largely developed, and thus more exposed to the action of such causes as directly affect it. If I am right in this, we would expect to see in women the emotional forms of insanity developed in excess of the same in men; and this is just what we find. Continuing to analyze the tables of Dr. Kirkbride relating to the same cases as above, we find the number of women to be 3,220, the number of men exceeding them by 459; and yet, there are 1,032 cases of melancholia among the women to 832 in men. Prof. Maudsley defines this form of insanity as "great oppression of the self-feeling, with corresponding gloomy morbid idea." [1]

The emotions, it is evident, are both the main recipients of the cause and the field of its morbid expression. Now, from what we know of the mental and physical constitution of woman, we should expect to find this form of insanity developed in excess of all others at the period of greatest sexual activity, and consequently of greatest

[1] "The Physiology and Pathology of the Mind," p. 320.

emotional sensibility. And here, again, our anticipations are realized by the figures. The interval between twenty and forty years constitutes this period in women. For these ages inclusive we have 1,923 cases of insanity against 1,297 cases for all other ages. It therefore follows that more than one-half the cases of insanity for this period were of melancholia. We can gain a clearer idea of the intensity of emotional activity in women by extending further the same line of comparison in regard to men. For the ages between twenty and forty inclusive we have 2,172 cases of insanity, and but 832 cases of melancholia for all ages. This shows a marked contrast in the liability of the sexes to this form of mental disease; for, at this period, the number of male cases exceeding the female by 200, yet the percentage of melancholia is thirty-three against fifty-three per cent. for women.

I do not believe that I err when I say that this excess in the emotional nature of woman over that of man is the outcome of physical and functional sexual traits, and is, consequently, another phase of sexual cerebration.

The above throws considerable light upon that peculiarity in woman's character so gracefully alluded to by George Eliot, and which I had so much difficulty in defining in the opening part of this article. This gentleness springs from woman's exquisite emotional susceptibility, as it is from the play of the emotions that this character becomes manifest. Having in view its origin in the emotions, and reaching its greatest development at the period of completion in woman's sexual genesis, the evidence of its existence as a form of sexual cerebration becomes complete. Were it otherwise, we would expect to see it obeying laws other than those of sexual development, and not existing in equal intensity during childhood, developed in excess of the male at womanhood, to disappear in the placidity of old age.

I have been using these statistics of insanity for the purpose of showing the extent of normal differences in the mental constitution of the sexes, and consequently of normal sexual cerebration. If we were to consider this in its abnormal phases, we would have opened before us another great field of investigation, the study of which would throw much light upon many problems of sex. Puerperal and gestational mania, the singular perversion of the maternal emotion attending lactation, are of special importance with reference to abnormal sexual cerebration. Hysteria, peculiarly a feminine disease, undoubtedly has its origin in sexual functional derangement, and is a striking example of the extent to which the emotional nature may be perverted by the abnormal actions of certain organs. Those cases of the social evil which break out from the purest domestic surroundings, and which defy all attempts at reform, are evidently due to the perversion of a healthful psychical state. The services of a skilled physician are needed to reform this class, and not the sentimental aid of reform societies, or the visits of the colporteur.

But here we are dealing with the healthy evidence of sex in mind. I have referred to but few of the many recognized intellectual states or processes, and yet they are sufficient to define differentially the average mental conditions of the sexes. With these as a basis of difference, the acuteness of intuitions, the vividness of imagination, and the want of intellectual belligerence, so often spoken of as traits of the feminine mind, and the existence of a modified or opposite form of these in the mental type of the other sex, can, with equal justice, be traced to sexual differences. Sex does not exist simply as a physical state; but we find it pervading organic life, and asserting itself potentially in every mental process. I believe the relation of the sexes in society bears to sexual cerebration the relation of cause and effect. Since the beginning of the historic age, under every variety of mental and physical conditions, the sexes have preserved their moral relations to each other almost unchanged. In what way can this be explained, except as the working of a natural law? There appears to me to be no law so adequate to explain this as that of sexual cerebration.

Several of the reviewers of a former paper seem to have regarded me as the avowed enemy of woman's social and moral advancement. I have entered upon the study of the relations of the sexes to the matters of daily life, with the single purpose of arriving at truth by the use of scientific methods. I believe the field gone over in this and former papers to belong properly to the student of Nature, and not to the so-called social reformer. I cannot bring myself to use the term "woman's sphere;" women have no sphere, except as it is defined by usefulness. I concede to woman the right to essay her fortune in any profession: I simply claim the right to courteously study her in her new relations. The ethnologist cannot be called the enemy of mankind, because he studies the different natural races of men; the botanist cannot be called the enemy of the rose, because he has analyzed its parts, and assigned it its place as a thing of beauty in the scheme of Nature.

## THE DEEPER HARMONIES OF SCIENCE AND RELIGION.[1]

II.

I HAVE suggested the thought of a God revealed in Nature, not by any means because such a view of God seems to me satisfactory, or worthy to replace the Christian view, or even as a commencement from which we must rise by logical necessity to the Christian view. I have suggested it because this is the God whom the present age actually does, and in spite of all opposition, certainly will worship, also because

[1] From a series of papers, in *Macmillan's Magazine*, on "Natural Religion."

this aspect of God is common to all theologies, however much in some it may be slighted or depreciated; and, lastly, because I do not believe that any theology can be real or satisfying that does not make it prominent as well as admit it. I can conceive no religion as satisfactory that falls short of Christianity; but, on the other hand, I cannot believe any religion to be healthy that does not start from Nature-worship. It is in the free and instinctive admiration of human beings for the glory of heaven, earth and sea, that religion begins, and I cannot imagine but as morbid a religion which has ceased to admire them.

But many readers will probably think that not much is to be hoped for from dwelling on this subject. "We know very well that the universe is glorious, but, when you have said that, there is an end of the matter. We want to make atheists believe in God, and you do it not by changing their minds, but by changing the meaning of the word God. It is not a verbal controversy that rages between atheists and Christians, but a controversy that concerns the most serious realities. When people display such rancor against religion as was shown by the Paris Commune, you may be sure there is some essential matter in dispute, and that nothing is more vain than to attempt to reconcile them by refining upon words. According to the definition you have given of theism, no rational being could ever be an atheist."

I will endeavor to answer this supposed objection at length, and the part of it which sounds the most formidable will give me the least trouble. That people do not shoot and stab each other for a word is not always true. In fact, when the word is theological that is just what people do. It has often been remarked of theological controversies, that they are never conducted more bitterly than when the difference between the rival doctrines is very small. This is nearly correct, but not quite. If you want to see the true white heat of controversial passion, if you want to see men fling away the very thought of reconciliation, and close in internecine conflict, you should look at controversialists who *do not differ at all*, but who have adopted different words to express the same opinion.

But the other question raised in the objection, the question whether there can be such a thing as atheism, will furnish me with a convenient point from which I may start for a fuller explanation of what I mean by the worship of God in Nature. As I have represented modern science as a form of theism, and as there is no rational man who does not believe—at least, in a general way—in science, it follows of course that no sensible man in these times can be speculatively an atheist. And I believe no one can, however many great philosophers may have congratulated themselves upon accomplishing that feat. If, then, no man could be an atheist practically without being one speculatively also, it would be true that men are entirely mistaken in the importance they attach to the distinction between theist and so-called atheist. It would then appear to be a misdescribed distinction, and to be in reality

only a distinction between two kinds of theists. This is what in common controversy it actually is. One might suppose beforehand that the theist and atheist must necessarily have the whole diameter between them, that their thoughts upon all subjects must be affected by this fundamental difference. It is not so in fact; the theist and the so-called atheist often indeed differ very widely, but sometimes also they think very much alike. This is, in reality, because one or other has been misnamed, for, between a real and thoroughly convinced theist and an atheist really deserving that name, there is almost as much difference as we could expect; only the latter character is not very easy to meet with.

An atheist in the proper sense of the word is not a man who disbelieves in the goodness of God, or in his distinctness from Nature, or in his personality. These disbeliefs may be as serious in their way as atheism, but they are different. Atheism is a disbelief in the existence of God—that is, a disbelief in *any* regularity in the universe to which a man must conform himself under penalties. Such a disbelief, as I have said, is speculatively monstrous, but it may exist practically, and where it does is an evil as fatal to character and virtue as the most timid religionist supposes. We may consider here, briefly, some of the forms which atheism assumes.

The purest form of atheism might be called by the general name of *willfulness.* All human activity is a transaction with Nature. It is the arrangement of a compromise between what we want on the one hand and what Nature has decreed on the other. Something of our own wishes we have almost always to give up; but by carefully considering the power outside ourselves, the necessity that conditions all our actions, we may make better terms than we could otherwise, and reduce to a minimum what we are obliged to renounce. Now we may either underrate or overrate the force of our own wills. The first is the extravagance of theism; it is that fatalism which steals so naturally upon those who have dwelt much upon the thought of God, which is said to paralyze, for example, the whole soul of the Mussulman. But the opposite mistake is a deficiency of theism; a touch of it often marks the hero, but the fullness of it is that kind of blind infatuation which poets have represented under the image of the giants that tried to storm heaven. Not to recognize any thing but your own will, to fancy every thing within your reach if you only will strongly enough, to acknowledge no superior power outside yourself which must be considered and in some way propitiated if you would succeed in any undertaking—this is complete willfulness, or, in other words, pure atheism. It may also be called childishness, for the child naturally discovers the force within it sooner than the resisting necessity outside. Not without a few falls in the wrestle with Nature do we learn the limits of our own power and the pitiless immensity of the power that is not ours. But there are many who cannot learn this lesson even

from experience, who forget every defeat they suffer, and always refuse to see any power in the universe but their own wills. Sometimes, indeed, they discover their mistake too late. Many barbarous races are in this condition. In their childishness they have engaged themselves in a direct conflict with Nature. Instead of negotiating with her, they have declared a blind war. They have adopted habits which they gradually discover to be leading them to destruction; but they discover it too late and when they are too deeply compromised. Then we see the despair of the atheistic nation, and its wild struggles as it feels itself caught in the whirlpool; then, a little later, we find that no such nation exists, and on the map its seat begins to be covered with names belonging to another language. Less extreme and unredeemed, the same Titanism may sometimes be remarked in races called civilized. Races might be named that are undergoing punishments little less severe for this insensate atheism. "Sedet æternumque sedebit," that unhappy Poland, not indeed extinguished but partitioned, and every thirty years decimated anew. She expiates the crime of atheistic willfulness, the fatal pleasure of unbounded individual liberty, which rose up against the very nature of things. And other nations we know that expect all successes from the mere blind fury of willing, that declare the word impossible unknown to their language. They color their infatuation sometimes with the name of self-sacrifice, and fancy they can change the Divine laws by offering up themselves as victims to their own vanity; they "fling themselves against the bars of fate;" they die in theatrical attitudes, and little know how "the abyss is wreathed in scorn" of such cheap martyrdom.

A wrong belief about God, however fatal it may be, is not atheism. Mr. Buckle tried to show that the Spanish empire fell through a false conception of the order of the universe; and it seems clear that the rigid Catholic view of the world is dangerous in this age to every nation that adopts it. These are the effects of false theology. But there is a state of mind which, though very far removed from the willfulness I have been describing, and often accompanied with a strong and anxious religiousness, may nevertheless be practically regarded as a form of atheism. It is the state of those minds which, fully believing in an order of the universe, yet have such a poor and paltry conception of it that they might almost as well have none at all.

People are sometimes led to this by a very reasonable and excusable process of thought. Naturally modest and distrustful of their own powers, they despair of understanding the order of the universe; they think it almost presumptuous to attempt to understand it. Wisely distrustful of any knowledge that is not precise, they avert their eyes instinctively from every thing which cannot be made the subject of such knowledge. In all their transactions with Nature, to use my former phrase, they make it a rule to be unambitious. They aim at objects very definite and very near. Whatever they gain they

make it a rule not to expose to any further risk. They avoid, as it were, meeting the universe in front, and endeavor to overcome it in detail. For its immediate purpose this plan is the best that can be pursued. If in all our actions we allowed ourselves to remember the greatness of the power with which we have to do, we should accomplish nothing; if, because Nature's laws are large and comprehensive, we never acted except on the largest principles, we should either fall a prey to unsound generalizations, the more ruinous because of their grandeur, or we should become paralyzed with a Turkish fatalism. Far better, no doubt, it is to make the utmost use of what precise knowledge we have, however little may be the amount of it, and not to suffer our minds to be bewildered by coping too freely with an adversary whose play is beyond us. It is these humble, cautiously inductive people that prosper most in the world up to a certain point. To them belong the large populations, the thriving communities, the stable politics. They never dream of defying Nature; they win an endless series of small victories over her.

There is no reason why this cautiousness should necessarily degenerate into little-mindedness. It does not take its beginning in any deficiency in the feeling for what is great. On the contrary, it is the direct result of an overwhelming sense of the greatness and, so to speak, the dangerousness of Nature. Those who proceed thus warily, probing Nature as they go, may with most reason expect to penetrate far and to elevate their minds gradually until they can venture to cope with the grandeur of the world and become familiar with great ideas. And when this is done they will have escaped the danger of atheism. Their minds will become the mirror of an Infinite Being, and their whole natures will be conformed to his. But in the earlier stages of such a process the temptation to a kind of atheism is strong. From the habit of leaving out of account all larger considerations in every problem, on the ground that they are vague and not precisely calculable, they are led easily to forget the very existence of such considerations. In some cases this habit even leads to great practical miscalculations. It is evidently a mistake in algebra to assume that all unknown quantities $= 0$; yet this mistake is constantly made by the practical men I am describing. When vague considerations are suggested to them, instead of assigning them an approximate value, which, since they cannot get the true value, is evidently what they ought to do, they leave them out of account altogether, though an indeterminate value may just as easily be large as small. But it is not with these practical mistakes that I am now concerned; practically these men are more often right than wrong, though in the exceptional cases, when every thing turns on a great principle, they fail deplorably. But the habit of never suffering the mind to dwell on any thing great produces often an atheism of the most pitiable and helpless kind. The soul of man lives upon the contemplation of laws or principles;

it is made to be constantly assimilating such sustenance from the universe; this is its food: *not by bread only, but by every word that proceedeth out of the mouth of God, doth man live.* What, then, must be the moral starvation of the man who, from an excess of caution, turns away from every thing of the kind, until from want of habit he can no longer see such things, and forgets their very existence; so that for him there is no longer any glory in the universe! For all beauty or glory is but the presence of law; and the universe to him has ceased to be a scene of law, and has become an infinite litter of detail, a rubbish-heap of confused particulars, a mere worry and weariness to the imagination. I have been describing the Philistine, the miserable slave of details, who worships a humiliated, dissected and abject deity, a mere Dagon, "fallen flat upon the grundsel-edge, and shaming his worshipers."

There is a particular form of conventionalism which all men who see it instinctively call by the name of atheism. By conventionalism generally, I understand the mistaking of institutions, usages, forms of society, which essentially are temporary and transitory, for normal and permanent forms. It is conventionalism, for example, when hereditary royalty or aristocracy are supposed to be not merely good institutions in particular cases but necessary in all countries and times. There is nothing at all atheistic in such a mistake; it is rather a superstition—that is, it is a false belief, but still a belief. The temporary arrangements are honestly confused with eternal laws, the feelings and views which in course of time have grown up around them are honestly mistaken for essential morality. The devoted adherents of the exiled Stuarts and Bourbons, the early Jesuits and the other champions of the counter-reformation, seem to me to have been such conventionalists. I think they confounded a transitory state of things with the sacred and eternal laws of human society. But for a long time their faith was genuine though mistaken. They had a God, and therefore they had vigor, and occasionally victory. But at the same time their belief was an ebbing tide. The movement of the age was, on the whole, against it; their successes always bore the marks of being accidental, and were followed in no long time by more than equivalent reverses. They could never give a character of reality to what they created; they could seldom feel quite easy and happy in their party strife. Their eloquence was copious and sonorous, but not often quite natural, and seldom convincing or overwhelming. And with such conventionalists, when the age puts them on their defense, these misgivings, this uneasiness, this constraint and depression go on increasing. Doubt penetrates them in spite of all their resistance, in spite of all the chivalrous devotion to their cause upon which they pride themselves. In the ardor of conflict they have pushed into the foreground all the weakest parts of their creed, and have got into the habit of asserting most vehemently just what they doubt most, be-

cause it is what is most denied. As their own belief ebbs away from them, they are precluded from learning a new one, because they are too deeply pledged, have promised too much, asseverated too much, and involved too many others with themselves. Thus their language becomes more and more vehement and hollow, more and more despairing under the mask of triumphant confidence. It may happen that the cause they defend is not merely unsound, but terribly bad, that what they have taken for sacred institutions are in reality monstrous abuses. Then, as they become reluctantly enlightened, as their advocacy grows first a little forced, then by degrees consciously hypocritical, until in the end their eyes are fully opened not only to the fact that their cause is bad, but, to all the enormous badness of it, there follows a complete moral dissolution of the whole man. Unable to abandon a position he is bound to, forced to act belief and enthusiasm when under the mask there is the very opposite of both—settled disbelief and utter disapproval—the man sees now in the universe nothing but a chaos. At the beginning he had a God; his actions were regulated by a law which he recognized in the universe; but now he recognizes this law no more, and yet is forbidden by his situation from recognizing any other. The link that bound him to the universe is snapped; the motive that inspired his actions is gone, and his actions have become meaningless, mechanical, galvanic. He is an atheist, a man without a God because without a law. Such men may generally be noted among the most intelligent adherents of expiring causes, demoralized soldiers, powerless for good and capable of any mischief.

These are specimens of what seems to me to be properly called atheism. The common characteristic of all these states of mind is feebleness. In the first example you have violent feebleness, impotence; in the second, cautious feebleness; in the third, cynical feebleness; but in all cases feebleness springing from a conscious want of any clew to the order of the universe. The specimens I have selected are all such as may be furnished by men of great natural vigor. The cynical atheist has often an extreme subtilty of intellect, the Philistine commonly begins with a great grasp of reality, a great superiority to illusions; the willful atheist has often much imagination and energy. Where a character wanting in energy is infected by atheism, you have those *αμένηνα κάρηνα* of which the world is at all times full. By the side of the profound cynic you have the mere lounger, who can take an interest in nothing, all whose thoughts are hearsays, never verified, never realized, not believed, not worthy of the name of prejudices—echoes of prejudices, imitations of hypocrisy. He moves about embarrassed and paralyzed by the hollowness of all he knows; conscious that nothing that he has in his mind would bear the smallest criticism or probation, knowing no way to any thing better, and meanwhile ingenuously confessing his own inanity. By the side of the over-judicious Philistine, who has fallen into feebleness through an excessive dread of general-

izing hastily, there may be seen the born Philistine, who does not know, and has never heard, what generalizing is, who becomes uncomfortable when he hears a principle enunciated, as if he had been addressed by a foreigner in some language unknown to him, and whose homely talk never willingly travels beyond what time the train starts, and whether it happened on Monday or on Tuesday. Lastly, by the side of the brilliant Utopian, who overlooks the greatness of the necessity with which he has to contend, there is the Utopian without brilliancy, the *enragé*, the mere restless disturber.

As atheism is but another name for feebleness, so the universal characteristic of theology—if we put aside for the present the rare belief in an utterly hostile or thwarting Deity—is energy. He who has a faith, we know well, is twice himself. The world, the conventional or temporary order of things, goes down before the weapons of faith, before the energy of those who have a glimpse, or only think they have a glimpse, of the eternal or normal order of things. And this vigor of theism does not much depend on the nature of the God in whom the theist believes. Just as atheism does not consist in a bad theory of the universe, but in the want of any theory, so theism consists not in possessing a meritorious or true or consoling theory, but simply in possessing a theory of the universe. He who has such a theory acts with confidence and decision, he who has no such theory is paralyzed. One of the rudest of all theories of the universe is that propounded by Mohammed, yet it raised up a feeble and dispersed nation to vigor, union, and empire. Calvinism presents assuredly a view of the universe which is not in any way consoling, yet this creed too gave vigor and heroism. The creed of the earliest Romans rested upon no basis which could for a moment pass for philosophical, yet while it was believed it gave order to the state, sanction to morality, victory to the armies. Whatever kind of theology be in question, so long as it is truly believed, the only danger is of its inspiring too much energy—of its absorbing its votaries too much, and driving them into extreme courses.

And so if the Nature recognized by Science be not benevolent, and have provided no future life for men, it does not follow that her votaries are not theologians, and it is quite clear that their theology gives them energy. Many theologies have had no future life; indeed, it is well known that our own, in its earlier Judaic form, laid no stress upon any future life. And it is not the benevolence of his Deity which gives so much energy and confidence to the convinced theist; it is rather the assurance that he has the secret of propitiating his Deity. It was not because Jupiter and Mars were benevolent beings that the Roman went out to battle confiding in their protection. It was because all sacrifices had been performed which the pontiffs or the Sibylline books prescribed. Just of the same kind is the theistic vigor which we see in modern science. Science also has its *procuratio*

*prodigiorum.* It does not believe that Nature is benevolent, and yet it has all the confidence of Mohammedans or Crusaders. This is because it believes it understands the laws of Nature, and knows how to deal so that Nature shall favor its operations. Not by the Sibylline books, but by experiment; not by supplications, but by scientific precautions and operations, it discovers and propitiates the mind of its Deity.

But by the side of this scientific theology decrying theology there is also a popular outcry against theology. The Revolution in Europe delights in declaring itself atheistic. The meaning of this in the main is, that it wishes to express in the tersest possible way its hatred of the reigning theology. But with this feeling there is no doubt a mixture of that real atheism I have described above under the name of willfulness. These revolutionists have so little conception of the greatness of the powers which determine the order of things, that they imagine they have only to make up their minds and to express their resolution with sufficient vehemence and to fling away their lives with sufficient recklessness, and human society will in a short time assume just the shape they wish. They think, in short, that they themselves are very great, and that Nature is very little. Still, it is evident enough that their hatred against the reigning theology is not a merely capricious feeling. It is no wild, egotistic grudge against whatever is powerful, however this feeling may occasionally blend with it. It is a serious, persistent, deep-rooted aversion. But it by no means follows that the reigning system excites their hatred purely as a theology, even though they themselves believe so. In their furious invectives against God, nothing is more evident than that they are thinking of a special conception of God, and, though they themselves do not profess to substitute any other conception, it is very possible they are unconsciously doing so. At any rate, the mere fact that these men are nominally atheists proves no more than is proved by the same name having been commonly bestowed upon the first Christians.

What, then, are the grounds of the irreconcilable repugnance of the Revolution for theology? Nothing is more easy than to distinguish and enumerate the principal ones. First may be ranked the political ground, that is, the intimate connection in which they find theology standing to the political system they are laboring to overthrow. Twice in modern Europe it has been possible to discern the interdependence of the reigning political with the reigning theological system. Modern history is filled with two great movements, the Reformation and the Revolution. The first was an attempt to purify religion, the second an attempt to reform government and society. In both cases the principal obstacle to the movement was found in the coalition of the Church and Government. The decided reaction against the Reformation which marks the second half of the sixteenth century, and which ended in restoring the mediæval form of Chris-

tianity in so many countries of Europe, seems to have been principally caused by the feeling of some courts, particularly the imperial court, that they could not afford to forfeit the support of the great Catholic organization, and by the corresponding disposition in Catholicism to ally itself with governments. The principle of saving the Church by the help of governments was avowed—Ranke tells us—by Pope Pius IV., and it was by this means that Catholicism was restored upon a new and strengthened foundation at the Council of Trent. What the Church owed to the state for protection against the Reformation it repaid two centuries later in assistance against the Revolution. A time had come round when the state was threatened as the Church had been, and now kings became faithful churchmen as the churchmen of Pius IV.'s school had before become faithful royalists. For half a century kings had coquetted with free-thought, and free-thought had flattered kings. But when the crisis came, and royalty was in danger, it hurried back to find shelter in the Church. Napoleon, Charles X., and the Emperor Francis, formed the new alliance by which theology was called in to drive out revolution in the state, just as Pius IV. formed the older alliance with royalty against Reformation in the Church. The natural effect of this coalition is to incline the Revolution to attack the Church at the same time that it assails Government. Atheism has become the creed of revolution because theology has been the traditional creed of monarchy and of privilege.

But is it true that theology is necessarily conservative or monarchical, because it happens to be true of the Christian Church, or the most prominent part of it, at this particular time? At particular times and places theology has been revolutionary. The earliest Christians must have seemed the most revolutionary party of the Greek and Roman world. Mohammedanism was so violently revolutionary that it completely transformed the Eastern world, and has caused almost the whole East to look back upon the ages preceding it as upon "times of ignorance." The same may be said of Buddhism in Asia. And certainly one form at least of Protestantism—I mean Puritanism—was revolutionary in spirit, and led either to an abridgment of royal power or to positive republicanism.

Hereditary royalty and aristocratic privilege were the institutions which, in the last century, the Revolution attacked. It was historically in the names of skepticism, and sometimes of atheism, that the attack was conducted. But there was no reason at all in the nature of things why the same attack should not have been made in the name of theology. In France, theology has been on the side of privilege, and equality has been associated with opposition to theology. But, in Turkey the opposite has happened; the equality of mankind has been preached, and successfully, in the name of theology. If a Christian preacher had been inspired to do so, he might with perfect warrant from his religion have proclaimed equality in France. Indeed,

this was to some extent what actually happened. Rousseau spoke partly in the name of theology, and even of Christian theology; and it was not until the skeptical foundation had been in a manner abandoned, and an appeal made to religion, that the spirit of political change awoke.

Indeed, to say that the Revolution has charged upon theology itself what is merely the defect of a particular theology, is a statement much short of the truth. The conservatism of the Church in the last ages is not principally due to the natural tendencies of the Christian religion. It is not so much Christianity as the Church that has been conservative. Church and government have been drawn together not so much from any natural sympathy—witness their perpetual conflicts in the middle ages—as by a common danger. All that can be said is, that in the hour of difficulty, when it was their obvious interest to combine, they have not found themselves so antipathetic that they could not do so. In neither of the two great crises was the help rendered by the one to the other disinterested. In the sixteenth century it was the Church that was threatened most; but governments were also uneasy, and took as well as gave in the arrangement they made with the Church. In the Revolution the state struggled for life, but the distress of the Church was almost as great. In these circumstances they would be driven into alliance even in the absence of any natural affinity, and being once in alliance would excite the indiscriminate aversion of the Revolution as if they had been natural allies. In one instance at least this has been strikingly realized. When the Revolution attacked monarchy and privilege, it was not very surprising that they should attack Christianity at the same time. Christianity is entirely silent on the question of liberty, and lends no support to those who contend against despotism. It has been used to defend despotism, and not without plausibility. It is not quite the same with privilege. Christianity is clearly favorable on the whole to equality, and yet even here its declaration is not very distinct. But in due time the Revolution, having conquered these enemies, went on to attack new ones. Leaving behind its mediæval monarchy and aristocracy, it proclaimed war against plutocracy. It proclaimed the principle of fraternity, fraternity between individuals as opposed to reckless competition in industry, fraternity between nations as opposed to war. Now, this new principle is not merely consistent with Christianity; to say this would be almost as absurd as to call it inconsistent with Christianity. It is neither more nor less than Christianity itself. Christianity is certainly not a socialistic system, because it is not, in that sense of the word, a system at all, but most assuredly Christianity furnished the ideas which the different socialistic systems are blundering attempts to realize. Not only so, but I believe that Christianity as a morality actually did nothing else, and that the modern word fraternity coincides exactly with the

moral side of Christianity. And when fraternity was first put upon the order of the day in 1848, this fact was to some extent recognized. Christianity actually played a certain part in that Revolution. But then followed a restoration of the old alliance between the Church and Government. For twenty years they continued accomplices in reaction. The consequence has been that when Revolution once more raises its head, it is no longer able to see the identity of fraternity and Christianity, nay, absolutely identifies Christianity with the negation of fraternity. How far it is possible to falsify an institution was never known to mankind until, in 1871, the Paris workmen assailed with irreconcilable fury the Church of Christ in the name of human brotherhood.

Thus the political repugnance of the Revolution to theology is in part merely a repugnance to an institution which has falsified the theology of which it is the depositary, and in any case is a repugnance not to theology as such, but merely to a particular theology. But the Revolution has also, no doubt, a quarrel with theology as a doctrine. "Theology," it says, "even if not exactly opposed to social improvement, is a superstition, and as such allied to ignorance and conservatism. Granting that its precepts are good, it enforces them by legends and fictitious stories which can only influence the uneducated; and, therefore, in order to preserve its influence, it must needs oppose education. Nor are these stories a mere excrescence of theology, but theology itself. For theology is neither more nor less than a doctrine of the supernatural. It proclaims a power behind Nature which occasionally interferes with natural laws. It proclaims another world quite different from this in which we live, a world into which what is called the soul is believed to pass at death. It believes, in short, in a number of things which students of Nature know nothing about, and which science puts aside either with respect or with contempt." Now, these supernatural doctrines are not merely a part of theology, still less separable from theology, but theology consists exclusively of them. Take away the supernatural person, miracles, and the spiritual world, you take away theology at the same time, and nothing is left but simple Nature and simple science. Thus theology comes to be used in the sense of supernaturalism, and in this view also excites the hostility of the age. Not merely scientific men themselves, for of these I am not now speaking, but liberals in general, all those who have any tincture of science, all whose minds have in any degree taken the scientific stamp, a vast number already, and, as education spreads, likely to become coextensive with civilized mankind, form a habit of thought with which they are led to consider theology irreconcilable.

It is a singular coincidence which has combined in apparent opposition to theology the two mightiest forces of the present age. Truly it is not against flesh and blood that Religion has to contend,

but against principalities and powers, that is, against the Revolution and against Science. Hasty minds, poetic imaginations, ready theorists, will never be content to see a mere coincidence in this. They will not admit that theology has been undeservedly charged with all the sins of that ancient corporation called the Christian Church, with which sins in reality it had nothing whatever to do. It is much more convenient to imagine the Church as the body of which theology is the soul, and to trace all the body's actions to the natural disposition of the informing soul. By this easy process we arrive at the conclusion that theology is an essentially conservative and stagnant principle, with the strongest natural affinity for despotism, privilege, respectability, and every kind of antiquated pretension; that, in short, it is a way of viewing the universe which inevitably leads to all the vices peculiar to old endowed corporations. And that an institution which is opposed to the Revolution should be at the same time at war with Science will never be thought a mere coincidence. Party spirit will be adroit enough to make it out that Science and Revolution are as soul and body on the one side, as theology and conservatism are on the other; that people who believe in miracles must necessarily side with capital against labor, and that large standing armies follow logically from a belief in benevolent design.

As to the mistake which lies in confounding theology with supernaturalism it is not necessary here to do more than repeat shortly what was said in the first chapter. First, then, there is no necessary connection between theology and supernaturalism. It is quite possible to believe in a God, and even a personal God, of whom Nature is the complete and only manifestation. Supernaturalism is part of the reigning theology, but it is not any necessary part of theology, as such. Secondly, when it is said that supernaturalism is *identical* with theology, this is not true at all, even of the reigning theology, i. e., of modern Christianity. Such a notion has sprung from a confusion of ideas. In the controversy between Christianity and Science it has become usual for shortness to give the name of theology (meaning Christianity) to that part of theology which science controverts. This is a very usual and, if rightly understood, a very harmless controversial practice. The agreements between theology and Science may very properly be overlooked by controversy which is only concerned with their differences. But it is the mistake constantly made by controversialists to adopt this abridged notation, as I might call it, outside the domain of controversy. For example, Catholicism means two quite different things according as the word is used in controversy or not. In controversy with Protestantism, Catholicism means worship of the Virgin and the saints, transubstantiation, purgatory. But no mistake could be more monstrous than to suppose that if all these doctrines were removed Catholicism would disappear. On the contrary, by far the larger half would remain—worship of God, worship

of Christ, heaven and hell, forgiveness of sins, the law of love. In the same way, in controversy with Science, Christianity (not theology) and supernaturalism are convertible terms. That is to say, if supernaturalism is refuted, Science wins and Christianity loses in the particular controversy in which they are engaged. In the controversial sense this is the destruction of Christianity, but only in the controversial sense. For when the worship of God outside Nature is taken away, the worship of God in Nature remains. Whether this residue is important or unimportant will be considered later; at any rate, it is there; and we may say at once that it would not be surprising if it should turn out more considerable than controversialists believe, when we remember how habitual it is for controversialists to exaggerate their differences, and generally how prodigiously exaggerated is the common estimate of the province of debate and dispute in human affairs.

At any rate, it is evident that the theology of the book of Job, of many of the Psalms, e. g., the 104th, of many passages in the Prophets, of many discourses of Christ, of many passages in the Epistles, would remain unaffected if supernaturalism were entirely abandoned. I will say no more at this stage.

On the whole, then, when we look at the great controversy of the age, what do we see? It is said that a furious attack upon theology is being made by the two distinct though allied hosts of Science and Revolution. But we see something essentially different. We see that what is called Science is indeed a most formidable power, against whomsoever she may declare war, but that her enemy is not theology, but supernaturalism, and that Science herself has all the character of a theology, not comforting or elevating like that she opposes, but not less capable of inspiring zeal and subduing the mind with conviction, and bearing in her hand a budget of practical reforms; and, moreover, that the Deity of her devotion is not different, but only a too much disregarded aspect of the Deity of Christians. The host of Revolution which we see approaching from another side is far less formidable. It is infuriated, but neither knows what it would overthrow nor what it would build. But we can see that its enemy is not theology at all, nor even supernaturalism, except in a secondary degree. It is enraged against an ancient corporation, which, having something mediæval in its constitution, like so many other corporations, has been led in the latest centuries to make common cause with other mediæval institutions which were endangered by the modern spirit. This corporation happens to be the depositary of a theology partly supernaturalistic, but we can see plainly that had it been the depositary of modern science itself it would have excited just the same animosity, nay, probably very much more, for in fact its creed in some aspects is in most remarkable agreement with the revolutionary creed itself.

The result, then, is this—of atheism, that demoralizing palsy of

human nature, which consists in the inability to discern in the universe any law by which human life may be guided, there is in the present age less danger than ever, and it is daily made more and more impossible by science itself: of revolt against the Christian law of fraternity, there is also less than ever in this age, and that redemption of the poor and that pacification of nations which Christianity first suggested are more prominent than ever among the aspirations of mankind. On the other hand, the organization of the Church seems ill-adapted to the age, and seems to expose it to the greatest danger; and, what is far more serious, the old elevating communion with God, which Christianity introduced, appears to be threatened by the new scientific theology, which, while presenting to us deeper views than ever of his infinite and awful greatness, and more fascinating views than ever of his eternal beauty and glory, denies for the present to him that human tenderness, justice, and benevolence, which Christ taught us to see in him.—*Macmillan's Magazine.*

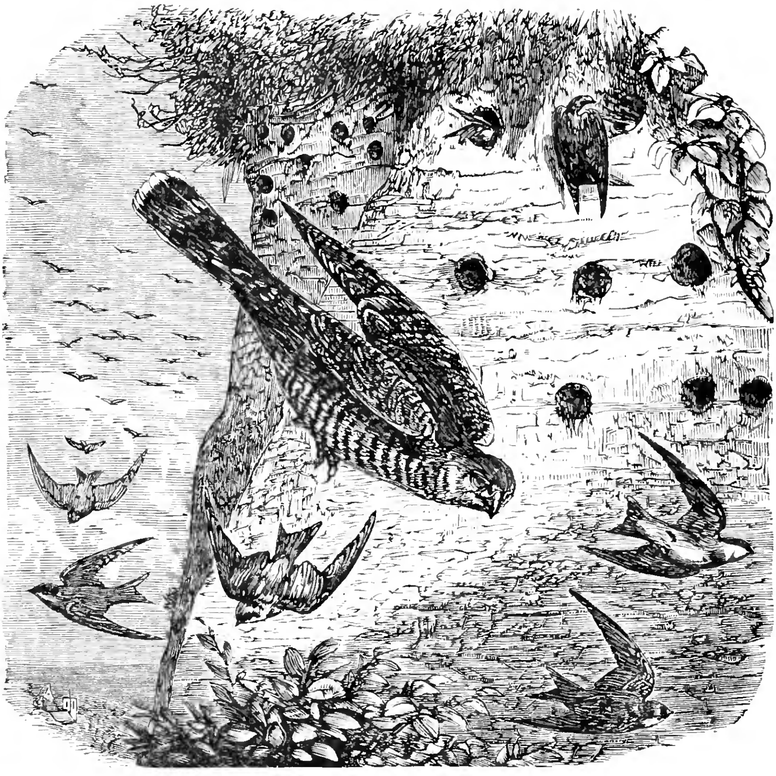
# THE BIOGRAPHY OF A BIRD.

By ERNEST INGERSOLL.

THE bird which is the subject of this sketch is familiar to all who walk in green pastures and beside still waters; for in such haunts do the *Bank-Swallows* congregate in merry companies, making up for their want of companionship with man, which is so characteristic of the other hirundines, by a large sociability among themselves. Conservator of ancient ways, it is almost the only swallow which has not attached itself to humanity as soon as it had opportunity, and changed from a savage to a civilized bird. Perhaps it, too, has tried it, long ago, and voluntarily returned to the fields; for our bank-swallow is a cosmopolite, and has watched the rise and fall of all the dynasties and nationalities that have grouped the centuries into eras, from Nineveh to San Francisco. It is at present an inhabitant of all Europe and eastward to China; of a large part of Africa, especially in winter; and throughout North America, the West Indies, Central America, and the northern Andean countries. On both continents its wanderings extend to the extreme north, where, in Alaska, it is one of the commonest summer visitors. So this modest little bird, smallest of his kind, is entitled to our respect as a traveler at least; and, to compare the habits and appearance of the representatives in different portions of the globe of so widely distributed a species, becomes a most interesting study.

*Cotyle riparia*, the bank-swallow, sand-martin, sand-swallow, river-swallow, *l'hirondelle de rivage*, or back-svala, is generally diffused over

the Northern Hemisphere though very unequally, avoiding those spots unfavorable to them. In this distribution they seem to have been somewhat influenced by man, though owing him no other favors than the incidental help of railroad-cuttings and sand-pits which have increased the sites suitable for their nests and enabled them to spread inland.



It is one of the earliest birds to arrive in the spring, appearing in Old England during the last week in March, and in New England early in May, many passing on to the shores of the Arctic Ocean, where Richardson, at the mouth of the Mackenzie, and Dall, on the Yukon, found them breeding in immense numbers. In these high latitudes its summer is necessarily a brief one, and September finds them back again picking up their congeners for company on the southward journey.

Where these and other swallows spend the winter was a hotly-debated question among ornithologists at the beginning of the present century; some affirming that they migrated with the sun, while others, believing it impossible that such small and delicate birds could endure the great fatigue and temperatures incident to such a migra-

tion, held that they regularly hibernated, during the cold weather, sinking into the mud at the bottom of ponds, like frogs, or curling up in deep, warm crannies, like bats, and remaining torpid until revived by the warmth of spring. Of this latter opinion was White, of Selborne, who alludes to it again and again, and Sir Thomas Forster wrote a "Monograph of British Swallows," apparently with no other object than to present the arguments for and against the theory of their annual submersion and torpidity. One of the difficulties which the *submersionists* put in the way of the *migrationists* was the frequent accidental and isolated appearance of the swallow before its usual time—a fact which has occasioned a proverb in almost every language. The French have, "*Une hirondelle ne fait pas le printemps;*" the Germans, "*Eine Schwalbe macht keinen Frühling;*" the Dutch, "*Een zwaluw maak geen zomer;*" the Italians, "*Una rodine non fa primavera;*" the Swedes, "*En svala gor ingen sommar;*" which all mean, *One swallow doth not make a summer.* The story is well known of a thin brass plate having been fixed on a swallow with this inscription: "Prithee, swallow, whither goest thou in winter?" The bird returned next spring with the answer subjoined: "To Anthony, of Athens. Why dost thou inquire?"

Out of this controversy, evidence of their sudden autumnal adjournment to Africa accumulated in England. Wilson, in this country, showed that their advance could be traced in the spring from New Orleans to Lake Superior and back again, and their regular migration soon came to be acknowledged. Then attention was turned to the season, manner and limits of their migrations, and it was found that, taking advantage of favorable winds, immense flocks of swallows—and many other birds of passage as well—flying very high, passed each fall from the coast of England to the coast of Africa, and from Continental Europe across the Mediterranean direct, whence they spread southward almost to the Cape of Good Hope. No sooner had the spring fairly opened than they were suddenly back again, very much exhausted at first with their long-sustained effort, but speedily recuperated and "diligent in business." Our own migrants, as I have mentioned, winter in Central America and the West Indies, or still farther south.

Their flight is rapid, but unsteady, "with odd jerks and vacillations not unlike the motions of a butterfly," as White describes it; and continues: "Doubtless the flight of all hirundines is influenced by and adapted to the peculiar sort of insects which furnish their food. Hence it would be worth inquiry to examine what particular genus of insects affords the principal food of each respective species of swallow." They are constantly on the wing, skimming low over land and loch, pausing not even to drink or bathe, but simply dropping into some limpid lake as they sweep by to sip a taste of water, or cleanse their dirty coats. It seems strange, then, that birds who sustain the

unremitting exertion of a flight scarcely less than 100 miles an hour in speed, during the whole of a long summer's day, should not be thought capable of the transition from England to Africa. However, at that time it was not well understood what long-continued flight small birds actually do make, as, for instance, from our coast to the Bahamas, or even across to Ireland, or from Egypt to Heligoland, 1,200 miles, which is passed over at a single flight by a certain tiny warbler, in every migration.

The bank-swallow is not a musical bird—a faint, squeaking chirrup being all its voice can accomplish. Nor is it a handsome bird, simply sooty-brown above, white beneath, with a brown breast. To its grace of motion, and charming home-life, we attribute that in it which attracts us so much.

Although probably the least numerous of all the swallows, they do not seem so, because of the great companies which are to be seen together wherever they are to be found at all; and because, leading a more sequestered life, they are not usually brought into direct comparison with house-martins and chimney-swifts. Eminently social in their habits, they congregate not only at the time of migration (then, indeed, least of all), and in the construction of their homes, but sometimes alight in great flocks on the reeds by the river-side and on the beach, where Sir William Jardine saw them "partly resting and washing, and partly feeding on a small fly, which was very abundant." Yet you will occasionally notice stray individuals associating with other swallows.

The secret of the local distribution of the bank-swallows lies in the presence or absence of vertical exposures of soil suitable for them to penetrate for the burrows, at the inner end of which the nest is placed. Firm sand, with no admixture of pebbles, is preferred, and in such an exposure, be it sea-shore, river-bank, sand-pit, or railway-cutting, the face will be fairly honey-combed with burrows, so that we can readily believe that Mr. Dall counted over 700 holes in one bluff in Alaska. These are usually very close together, and the wonder is how the birds can distinguish their own doors. If mistakes do occur, I imagine they are very polite about it, for I know of no more peaceable bird than they. The mode in which this perforation, requiring an amount of labor rare among birds, is performed, is well described by Mr. Rennie, in his "Architecture of Birds:"

"The beak is hard and sharp, and admirably adapted for digging; it is small, we admit, but its shortness adds to its strength, and the bird works . . . . with its bill shut. This fact our readers may verify by observing their operations early in the morning through an opera-glass, when they begin in the spring to form their excavations. In this way we have seen one of these birds cling with its sharp claws to the face of a sand-bank, and peg in its bill as a miner would his pickaxe, till it had loosened a considerable portion of the hard sand, and tumbled it down among the rubbish below. In these preliminary operations it never makes use of its claws for digging; indeed, it is impossible that it could, for

they are indispensable in maintaining its position, at least when it is beginning its hole. We have further remarked that some of these martins' holes are nearly as circular as if they had been planned out with a pair of compasses, while others are more irregular in form; but this seems to depend more on the sand crumbling away than upon any deficiency in its original workmanship. The bird, in fact, always uses its own body to determine the proportions of the gallery—the part from the thigh to the head forming the radius of the circle. It does not trace this out as we should do, by fixing a point for the centre around which to draw the circumference: on the contrary, it perches on the circumference with its claws, and works with its bill from the centre outward; . . . the bird consequently assumes all positions while at work in the interior, hanging from the roof of the gallery with its back downward, as often as standing on the floor. We have more than once, indeed, seen a bank martin wheeling slowly round in this manner on the face of a sand-bank when it was just breaking ground to begin its gallery.

"This manner of working, however, from the circumference to the centre unavoidably leads to irregularities in the direction. . . . Accordingly, all the galleries are found to be more or less tortuous to their termination, which is at the depth of from two to three feet, where a bed of loose hay and a few of the smaller breast-feathers of geese, ducks, or fowls, is spread with little art for the reception of the four to six white eggs. It may not be unimportant to remark, also, that it always scrapes out with its feet the sand detached by the bill; but so carefully is this performed that it never scratches up the unmined sand, or disturbs the plane of the floor, which rather slopes upward, and of course the lodgment of rain is thereby prevented."

Sometimes the nest is carried to a far greater depth than two or three feet, as in a case observed by Mr. Fowler, in Beverly, Massachusetts, where, in order to get free of a stony soil where pebbles might be dislodged and crush the eggs, the tunnel was carried in nine feet, while neighboring birds in better soil only went a third as far. In one place the burrows will be close to the top of the bluff, in another near the bottom, according as fancy dictates, or the birds have reason to fear this or that enemy. English writers agree that occasionally their bank-swallows do not dig holes, but lay in the crannies of old walls, and in hollows of trees. This is never done, that I am aware of, in the United States; but in California a closely allied species, the rough-winged swallow, "sometimes resorts to natural clefts in the banks or adobe buildings, and occasionally to knot-holes." On the great Plains, however, our *Cotyle* burrows in the slight embankments thrown up for a railway-bed, in lieu of a better place.

"How long does it take the bird to dig his cavern under ordinary circumstances?" is a question which it would seem hard to answer, considering the cryptic character of his work. Mr. W. H. Dall says four days suffice to excavate the nest. Mr. Morris, a close observer of British birds, says, *per contra*, that a fortnight is required, and that the bird removes twenty ounces of sand a day. Male and female alternate in the labor of digging, and in the duties of incubation.

When the female is sitting, you may thrust your arm in and grasp

her, and, notwithstanding the noise and violence attending the enlargement of the aperture of her nest-hole, she will sit resolutely on, and allow herself to be taken in the hand with scarcely a struggle or sign of resistance—even of life, sometimes. The young are fed with the large insects which the parents catch, particularly those sub-aquatic sorts which hover near the surface of still water; and White mentions instances where young swallows were fed with dragon-flies nearly as long as themselves. The young do not leave the nest until they are about ready to take full care of themselves. Finally, they are pushed off by the parents to make way for the second brood, and, inexperienced in the use of their wings, many fall a prey to crows and small hawks that lie in wait ready to pounce upon the first poor little fellow that launches upon the untried air. Those that manage to run the gantlet of the hawks, collect in small companies by themselves and have a good time hunting by day, and roosting at night among the river-reeds, until the autumn migration. "At this time Salerne observes," says Latham, "that the young are very fat, and in flavor scarcely inferior to the *ortolan*." Sometimes the parents forsake their progeny in the nest, and seem generally to care less for them than is usual among swallows.

But not the young alone are exposed to enemies. It would seem as though the situation of the nest precluded invasion, yet if they are near the haunts of the house-sparrow they are sure to be dispossessed of their homes by that buccaneer. Snakes, too, can sometimes reach their holes; weasels, like that one Mr. Hewitson tells us of, are often sharp enough to make their *entrée* from above: school-boys regard the pink-white eggs a fine prize; and, last and worst of all, the bank-swallows are many times utterly worried out of their galleries by fleas and young horse-flies, which swarm and increase in their nests until the bird finds endurance no longer a virtue, and digs a new *latebra*.

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# RECENT POLAR EXPLORATIONS.

TRANSLATED FROM THE FRENCH, BY EMMA M. CONVERSE.

THE regions called circumpolar, during the last six or seven years, have been the theatre of numerous explorations that have enriched our geographical maps with many new outlines. Doubtless, the recent discoveries have not succeeded in penetrating the mystery that envelops the arctic world, but, by strength of will, and thanks also to the connivance of chance—sometimes propitious to navigators—important points of departure have been obtained from extreme latitudes. It is well known that there are four distinct routes for approaching the basin of the Arctic Ocean: One, by Behring Strait, is formed by the

rent found between the northeastern point of extreme Asia and the very jagged promontories of the northwestern coast of North America. This was the route chosen by the Frenchman Gustave Lambert for that gigantic expedition, the preparations for which were followed with great interest by the learned world; but his unexpected death caused the abandonment of the enterprise. A second route, by Baffin's Bay, opens between the western shores of Greenland and the vast archipelago that commences at Hudson's Bay. This double entrance to the arctic seas has been for a long time the favorite course for English and American sailors. Europe, at the present time, seems to prefer two routes nearer its own territory, passing, the one, along the eastern coast of Greenland, the other between Spitzbergen and Nova Zembla.

These last-mentioned routes were formerly much frequented by the Dutch navigators like Barentz, but they have since been abandoned. Dr. Petermann, the director of the *Geographische Mittheilungen*, has succeeded in bringing once more into popular favor these desirable paths to the Polar Sea. Extensive and long-continued study gave to this geographer the conviction that the great warm current that issues from the Gulf of Mexico, between Florida and the island of Cuba, and takes a northern course, passing along the coast of Europe, must have a northern extension more considerable than had been heretofore supposed. In the month of July, 1865, Dr. Petermann for the first time developed this theory before the German Geographical Society in session at Hamburg. Supporting his argument by numberless experiments in soundings and measurements of temperature, he demonstrated the probable presence of the Gulf Stream in very high latitudes, and concluded that, after leaving Spitzbergen, the barrier of ice once overcome, a navigable ocean would be found. The routes that we have described would then be openings conducting to a kind of arctic Mediterranean, to which navigators could sail in a direct course, instead of wasting their lives in perilous and useless searches in the windings of the great circumpolar labyrinth. These bold deductions did not fail to meet with energetic opposition, especially in America and England; but five years later, in 1870, Dr. Petermann, returning to the charge with the data gained from a still more complete research, surmounted all controversy. He established the fact that the warm current advances as far as Spitzbergen and Nova Zembla, beyond the eightieth degree of latitude, and that, aside from some lateral branches, it sends its principal mass toward the northeast. At this latitude the temperature of the current descends to three degrees below zero, Centigrade. Experiments made by Dr. Bessels, of Heidelberg, in the course of one of the latest explorations, prove that the influence of the warm current is still perceptible beyond Bear Island. The real extent of the Gulf Stream is, however, a problem that has never been satisfactorily solved.

The scientific agitation fomented in Germany by the speeches and writings of Dr. Petermann did not delay to bear fruit, although the theory of the eminent geographer has not received the sanction of direct proof, which it still awaits. In 1868 a first expedition, under the command of Captain Koldewey, a sailor, educated at the school for pilots in Bremen, set sail from the port of Bergen. Although imperfectly fitted out, it had for a special mission to take the bearings of the northern prolongation of the east coast of Greenland. In case the explorer could not attain this coast, he must endeavor to refind on the east of Spitzbergen the famous land of Gillis, discovered in 1707 by the Norwegian Gilles, and since then forgotten and lost. The Germania (such was the name of the ship chartered for this purpose) directed her course toward the eastern coast of Greenland; but the agglomeration of ice preventing her approach, she turned toward the west coast of Spitzbergen, and then reascended toward the north a little beyond the eighty-first degree. Although the expedition was obliged to deviate from the path marked out, it was not without interest for the progress of hydrography and physical geography. It discovered that King William's Island, situated in the strait of Henlopen, was really an island, as Scoresby had indicated in 1822; and it corrected the boundary of Northeast Land, one of the largest islands of Spitzbergen. Besides, the year 1868 did not appear to be favorable for an attempt at landing on the east coast of Greenland, for the Swedish steamer Sophia, which made the same attempt under the command of Captain Baron de Otter, could not pass the icebergs, and was obliged to return in October, a month after the Germania.

The impulse once given was not allowed to diminish its force. Thanks to the zeal of Dr. Petermann, seconded by an indefatigable ship-owner of Bremerhaven, Mr. Rosenthal, the next year, 1869, numbered a dozen expeditions, almost all sent forth by the routes recently reopened. In February, the screw-steamer Bienenkorb left the Weser for the purpose of attempting a landing on the east coast of Greenland. The ice once more prevented the success of the enterprise. In May, another steamer, the Albert, commanded by Captain Haasgen and Dr. Bessels, set out to make the tour of Spitzbergen, to explore the sea between this land and Nova Zembla, and to discover, if possible, the land of Gillis. None of these three objects were accomplished, but the expedition determined more exactly the situation of the islands southeast of Spitzbergen, and confirmed the assertions of Dr. Petermann upon the distant extension of the Gulf Stream. The same year the English Captain Palliser, having for an object to sail around the shores of Nova Zembla, penetrated into the Sea of Kara, situated between that island and the Samoiede peninsula, and sailed along the Siberian coast, within a few leagues of White Island, without being at all impeded by the ice. Behind him, the Norwegian Johannesen traversed the same route twice without encountering any difficulty. By this

means the commonly-received belief was corrected, which represented as narrow and of little depth this basin, into which, by two neighboring estuaries, are poured the congealed masses of the Obi and Yenisei, as if it were the great ice-house of the north-pole.

The most important event of the year 1869, in the order of facts, was the second German expedition, which departed in June from Bremerhaven. This expedition, fitted out at great expense through the zeal of numerous committees, was composed of two ships, the screw-steamer Germania, seasoned already by a preceding exploration, and the sailing escort Hansa. Captain Koldewey, the commander-in-chief, was assisted by the Austrian Lieutenant Julius Payer, and several scientists. The instruction given to the voyagers, by the Central Committee of Bremen, marked out for them the eastern coast of Greenland as the principal base of operations, and the object to be accomplished was to study it scientifically, and to examine it in all its details. These labors completed, Mr. Koldewey and his companions would, if circumstances were favorable, direct their course as far as possible toward the pole; but, in any event, the extreme date of return was fixed upon the first of November of the following year. The two ships kept company, through good and evil fortune, as far as the seventy-fourth degree of latitude; there, a fatal error, a signal of the Germania incorrectly interpreted on board the sailing-vessel, separated the two ships forever. The Hansa, not having at command the resources of steam, was soon invested by the ice, about forty miles from the coast, and, after having, in this position, drifted considerably to the south, broke to pieces under the pressure of the ice-blocks that surrounded her. The crew sought safety upon an immense piece of floating ice, where they built of coal a winter hut that was destroyed in its turn. This new species of raft, which was at first seven miles in circumference, broke up or gradually melted during a perilous and capricious drift of six months, a part of the time in the darkness of a polar night, until at last the hour came when the unfortunate sailors measured only with anxiety the surface of their fragile domain. Happily, the current had carried them insensibly to more hospitable latitudes, and, as they had saved their boats, they seized the first occasion to set them afloat. Finally, by force of sail, towing, and transshipment, they reached Friedrichsthal, a missionary station situated at the southern point of Greenland, then Lichtenau, and Julianshaab, where they found a steamer that landed them at Copenhagen on the first of September.

The Germania, more favored, had meantime the glory of accomplishing to the letter the very precise instructions of the committee of Bremen. The history of the voyage, filling four large volumes, deserves the closest attention, and will remain, until new discoveries are made, the indispensable manual of the navigator in the eastern part of Greenland. The difficulty of gaining access to these coasts, situ-

ated beyond the influence of the Gulf Stream, proceeds from the enormous quantity of ice carried by the polar current in this direction. The principal chance of success depends upon the direction of the prevailing winds. East and southeast winds render the icebergs more resistant and more compact; west and northwest winds, on the contrary, by driving back the blocks of ice in an opposite direction, cause a division and a crumbling that disentangle the labyrinths near the shore, and open numerous passes.

The Germania had this experience. During the month of July she struggled in vain against insuperable agglomerations of icebergs and ice-fields welded to each other. It was not till the commencement of August, when the predominance of breezes from the Atlantic had produced a loosening of the ice driven back between Iceland and Spitzbergen, that the ship opened a passage, and effected a landing in a small bay of Sabine Island, in the Pendulum Archipelago, below that part of the country called King William's Land.

It is well known that Greenland, visited several times from the tenth to the fifteenth century, then completely abandoned and lost, was rediscovered at the end of the sixteenth century by some Scandinavian sailors. The eastern shore, particularly, is only known since the voyages accomplished from 1822 to 1831, by Scoresby, Clavering, Sabine, and Graah; we do not speak of the unfortunate attempt made at the same epoch by the Frenchman, Jules de Blossville, who disappeared with his ship, and was never heard of afterward.

This eastern coast, relatively level from Cape Farewell, the extreme southern point, as far as Scoresby's Sound, suddenly changes its character as soon as the seventieth degree is passed. It offers at this latitude an infinity of bold promontories, deep and sinuous fiords, fantastically collected, with backgrounds bristling with gigantic glaciers, in comparison with which the most famous ones of Switzerland singularly lose their majesty. All this jagged, solid mass, has for an advance-guard a projection of islands generally very mountainous; the whole figure recalls a little the aspect of the coasts of ancient Asia Minor. The Germania penetrated into the centre of this labyrinth. As soon as she was anchored in her harbor, it was evident that she must remain a prisoner. The masses of iceberg, though temporarily affected by the summer heat, manifested no symptom of breaking up, and the channels, opened between the islands and the continent, began to close during the middle of August. According to the account of explorers, the formation of ice takes place in this manner. Small, isolated denticulations are accidentally formed near each other, without presenting at first any appearance of cohesion. Afterward a thick paste is produced, which is finally amalgamated into a crust, and this crust is so flexible that it reproduces without breaking the swelling of the surge. By the middle of September this ice could sustain the weight of the sleds. Mr. Koldewey and his companions improved the

opportunity, by the assistance of these vehicles, to visit several points of their archipelago; unfortunately, the autumn excursions in these lands continue only about five or six weeks. In the first days of November, the crew of the Germania saw the sun disappear for three long months beneath the horizon. Then commenced that terrible captivity in the midst of the polar night, and among frightful storms of snow.

The winter of 1869–'70 was made remarkable by a series of tempests from the north, one of which continued for more than a hundred consecutive hours with a velocity of about sixty miles an hour. The thermometer at the same time did not fall beyond 32° (Centigrade) below zero. Besides, even in the most severe temperature, if the chinks in the cabins are carefully stopped up, if the access to the ship is well defended by artificial casings of ice and snow, there will be little suffering from cold. The physical and moral discomfort arises principally from the impossibility, during more than ninety days, of observing the surrounding phenomena, and from the long-continued immobility in the midst of sinister darkness, illuminated alone by those strange celestial fairy scenes called aurora borealis. Outside, the congealed masses of every age and production, being pushed against each other with inimitable noises and grindings that sailors call "the voices of the ice," are welded in huge rafts, or form pyramidical entablatures sculptured with gigantic stalactites. The ship, however, well sheltered in a harbor open on the southern side, and protected on the north by a high rampart of mountains, can brave this frightful shock of the elements; but every thing depends, in case of emergency, on the fortunate choice of a station. The essential point is that the blockade, that assures the safety of navigators, should remain unbroken, and that no ricochet movement should reach the ship; the least rupture of the plain of surrounding ice, the least bar would be fatal; the most fearful peril is the neighborhood of running water.

The polar night, in the latitude where the Germania wintered, ended at the commencement of February; a month after, the sun remained long enough above the horizon to allow great sledge excursions. Then the truly scientific labor of the explorers commenced. This task represents a series of Herculean labors that baffles the imagination. The country not offering the least resource, the travelers were obliged to carry every thing with them; the heavy vehicle also played the *rôle* of that "ship of the desert," whose loss involves that of the whole caravan. Clothed with heavy furs, the face entirely masked, the tourists harnessed themselves to the sled; supported in some fashion in their hard effort in towage, they struggled against the cutting north wind. The eye, beset by the monotonous reflection of the white immensity, knew neither where to rest nor how to judge of distances; it was every moment the sport of mirages that vanished

to spring up again in another part of the horizon with the most deceptive effects of refraction. The activity and wakefulness of the nights increased the suffering of these marches where a geographical enigma was mingled, as it were, with every step, and where it was often the work of a whole day to accomplish a simple advance of a quarter of a league; but of what is not the constancy of man capable when science is the object of pursuit! The pioneers of the Germania advanced thus beyond the seventy-seventh degree of latitude by 18° 50′ west longitude from Greenwich. This year, at least, there was no trace of an open sea toward the pole, on the Greenland coast. Everywhere, on the north and east, the sea appeared to be solidly bridged by the ice. If provisions had not failed, the traveling colony would have been able to push on the sled indefinitely over these boundless plains. The iceberg, properly so called, without remarkable protuberances, extended for about two leagues from the shore, which, starting from this extreme point, seemed to take a northwest direction, where the perspective was obstructed by high mountains crowned with glaciers.

During the two following months, the voyagers explored, either in sleds or boats, the deep bays and fiords of the estuaries west and south of the Pendulum Islands. In the month of May, even in this high latitude, signs precursory of the fine season were manifest, and the first fruits of the meagre Greenland vegetation were seen in all directions. Under the bridges of snow and the coverings of the glaciers, the murmur of running water was heard; long flights of eider-ducks arrived from the south; the polar ortolan warbled its sweet note; the *lemmings*, a kind of northern rabbit, were seen among the fragments of the rocks; the white hares enjoyed the young sprouts of moss and saxifrage; while the reindeer, with its slender body, enlivened the depths of the torrents, and, at a distance, the curious head of the seal emerged through the sheets of ice, brightened and mellowed by the sun.

At last, on the 22d of July, 1870, the Germania floated once more in the open sea, and, after having remained 300 days in winter quarters, quitted the little harbor that had hospitably received her, in order to attempt, by the aid of steam, further progress toward the north; but, in latitude 75° 26′, a little less than the height she had attained the preceding summer, the channel suddenly failed. The summer influences had not disintegrated the enormous masses bound to the iceberg, and apparently this soldering would yield only to the autumnal tempests. But, these tempests coming at the end of August, the Germania, which, according to the instructions of the committee of Bremen, could make but one winter in these regions, resolved to return to Europe, and she was alongside the wharf in the Weser on the 11th of September.

The scientific results of the exploration were, on the whole, considerable. If the principal problem of polar navigation had not been solved, much more precise and extended notions concerning the physi-

cal and hydrographic nature of the most important northern country were attained. Mr. Koldewey, when he asserts that no continuous channel exists on the east of Greenland, draws perhaps too rigorous a conclusion from a simple experience of two years. But it appears doubtful whether, under any conditions, this coast can offer a favorable base for reaching the central basin of the north-pole, for, on one hand, the state of the channel near the shore is subordinated to all kinds of topical conditions difficult to foresee, and, on the other, the cold current, even at the season of the greatest loosening of the ice, causes immense quantities of huge blocks to drift in that direction. The country itself presents also to the scientist and geographer a very curious field for observation. The officers of the Germania found, from investigations skillfully conducted, that this part of Greenland is actually inhabited, and that it seems also habitable. They discovered the perfectly preserved remains of Esquimaux huts, veritable houses that the history describes very minutely, containing different instruments and utensils, whose primitive fashion recalls the work of the Stone age; but, for some reason, the polar man seems to have deserted, without a desire to return, these quarters, where the conditions of life, during the progress of ages, have been sensibly modified. The polar bear, improperly called the white bear, reigns as master among the glaciers of the coast, as the walrus, no less dreaded, reigns on the icebergs of the sea.

The most intelligent and the most active member of the important mission whose fortune we have followed, was undoubtedly Lieutenant Julius Payer. This officer, devoted heart and soul to the theories of Dr. Petermann, set out the next year (1871) with his countryman, Lieutenant Carl Weyprecht, to search for the land of Gillis. The two explorers did not succeed in finding it; but they penetrated 150 miles farther north than their predecessors had done in this region. Beyond the seventy-eighth degree, between 42° and 60° west longitude, there was still an open sea, and the temperature of the surface of the sea varied between three and four degrees (Centigrade) above zero. The want of provisions obliged the crew to turn back, and this was a great misfortune, for the year seemed exceptionably favorable. The Norwegian captain, Mack, who traversed at this time the eastern part of the same ocean, in search of the place where Barentz had wintered in 1579, met everywhere, at a distance that no one had before attained, navigable water with a strong current. The station of Barentz was, however, found a short time after on the northeast point of Nova Zembla by another Norwegian, Carlsen; it still preserved visible tokens of the abode of the Dutch navigator.

Another expedition, resembling the abortive voyage of the Hansa, in its dramatic catastrophe, if not in its results, was undertaken in this same year (1871) by the American captain, Hall, who adopted the route by Baffin's Bay, instead of the European entrance to the

Arctic Ocean. Captain Hall, in company with Dr. Bessels, starting from Newfoundland on the 29th of June, on the ship Polaris, shaped his course toward Smith's Strait, discovered by Kane seventeen years before, and at the end of August landed on Grinnell Land, in 80° north latitude. He ascended afterward to Kennedy's Channel, and penetrated into a narrow sound for about 100 leagues, where no mariner had ever ventured before. This passage was called Robeson, in honor of the Secretary of the Navy of the United States. Captain Hall advanced by this new route, that probably ended in the famous central arctic basin, as far as latitude 82° 16′, touching the extreme point on the 3d of September. There he perceived on the north a vast extent of open water that he called Lincoln Sea, and farther on another ocean, or a bay, on the west of which the outlines of a coast were delineated; this country was named Grant Land. Everywhere a fauna appeared similar to that of Greenland; herds of musk-oxen, white hares, and other polar animals, were seen, and they even thought that traces of human beings were perceptible. The crew was eager to make an opening through the iceberg; but the sailing-master of the expedition, Captain Buddington, would not permit the attempt, and the Polaris returned to winter in Robeson's Channel, in latitude a little above 81°. The death of Captain Hall, occurring in the month of November, put an end to every new endeavor to make any further advance on the northern coast; the winter was passed in inaction, and when the warm breath of the following summer had put the waters in motion, and delivered the Polaris from the fetters that bound her, the travelers hastened to descend to the south. The return was not entirely unimpeded. The ship underwent a terrible pressure; a part of the men, separated by chance from their companions, took refuge on an ice-floe, where they remained miserably stranded for 240 days. This ice-field, like the one that bore the waifs of the Hansa, was constantly drifting toward the south, and visibly shrinking, until, on the 30th of April, the shipwrecked sailors were seen by a passing steamer. As to the rest of the crew of the Polaris, obliged to abandon the leaky ship, they wintered on Littleton Island, whence they set out once more, on the following summer, in two boats procured from a Scotch whaler.

All these eventful voyages, so curious and exciting, are surpassed by the recent exploit of the steamer Tegethoff, whose almost fabulous experience was only known in Europe during the month of last September. Lieutenants Payer and Weyprecht, immediately after their return from the expedition of 1871, were detailed to prepare a new one. Nothing was neglected to give a character of unusual grandeur to this exclusively Austro-Hungarian enterprise. Two eminent friends of science, the Counts Wilczek and Zichy, lent to it their material and moral aid; the Royal Geographical Society, in February, 1872, advised the formation of a special committee, including among its members the most

illustrious names of the Austrian aristocracy, and a considerable sum of money was soon collected. The equipment of the mariners was the object of careful solicitude; they were so provided for that, without dreading cold and snow, they might go away hundreds of miles from the ship and be absent for months. The principal aim of the expedition was to study the unknown regions of the Polar Sea north of Siberia, and to see if it were possible to reach Behring Strait by this route; it was only as a secondary object, a kind of last resort, that the expedition could direct its course toward extreme latitudes; it was only permitted to venture in the direction of the pole if, in the course of two winters and three summers, it did not succeed in doubling the extreme promontory of Asia. The point of official departure of the scientific excursion was the northern coast of Nova Zembla.

The Tegethoff, having on board twenty-four persons, set sail from Tromsoë, Norway, on the 14th of July. Some days after a yacht sailed from the same port with Count Wilczek on board, whose purpose was to establish on an eastern point of the Arctic Ocean a depot of coal and provisions for the Tegethoff. On the 21st of August, off Cape Napan, between Nova Zembla and the mouth of the Petchora, the yacht lost sight of the steamer. More than two years passed before any news was received of the missing ship. Great was the anxiety in Austria and in the whole civilized world; heaven and earth were moved to aid the navigators who had so strangely disappeared. Count Wilczek had a quantity of small India-rubber balloons made, which, supplied with dispatches, were distributed to the whalers sailing for the northern seas, with directions to let them loose in the different stations of these territories. The Geographical Society of London gave an express mission to a ship bound for Spitzbergen, to inquire everywhere for the Tegethoff. The Russian Minister of the Navy, Mr. Siderof, instigated a public reunion for the purpose of sending a salvage expedition upon the traces of the unfortunate steamer.

Suddenly, on the 3d of last September, just at the epoch predicted by Dr. Petermann, who had constantly maintained that news of the explorers must not be expected before the autumn of 1874, a report was spread abroad from Vienna that the lost sailors had just landed in Europe. Some days after they made their entrance into the Austrian capital, welcomed by enthusiastic cheers whose echoes are still heard. The expedition, as often happens in these unconquerable polar seas, was not able to follow the terms of the official instructions. The Tegethoff, from the 21st of August, 1872, the same day when Count Wilczek saw her for the last time, found herself irretrievably invested by ice. In endeavoring to get free from this fatal imprisonment, the crew and the ship remained the passive sport of chance; on the 13th of October, the vessel received a thrust that lifted it up, and inflicted upon it heavy bruises. Let any one judge how agitated and terrible

this winter harbor was, at the mercy of the elements! The ice was in constant movement until the spring of the following year. At the end of March, 1873, the pressure came to an end, but the Tegethoff was incrusted in the midst of a plain of ice several leagues in circuit. For five months, from April to September, the crew worked in vain to restore the ship to its normal condition; the ice-plain in which it was incorporated was pushed by the winds in every direction, and at last ascended to 79° 54′ north latitude. The *rôle* of science then unexpectedly commenced; a consoling light for the mind and will of the explorers burst forth even from the bosom of blind fatality. On the 31st of August, 1873, after more than a year of terror and endurance, the ice-bound captives saw a mass of elevated coast, sparkling with glaciers, emerging from the fog, at a distance of about fourteen miles. They immediately gave to this apparition the name of Emperor Francis Joseph's Land. But it was not till the end of October that they were able to land on shores so miraculously discovered; even then, on account of the advanced season, they found it impossible to take possession; for they were soon to enter for the second time into the sinister polar night that continues three and four months. They took advantage of the last days that were illuminated with an expiring twilight to make little preliminary excursions some leagues from the ship, and this was all they could accomplish. They were then obliged to wait patiently for the next dawn of day, that is, until the spring of 1874.

This winter was more tempestuous than the preceding, and the persistent north winds brought interminable snow-storms; the thermometer fell to 48° (Centigrade) below zero. At last, on the 24th of February, the sun having reappeared above the horizon, they hastened to improve the spring weather. Lieutenant Payer prepared three expeditions with sledges drawn by dogs to reconnoitre the nature and configuration of the neighboring land. In the first excursion, from the 10th to the 16th of March, he visited the nearest island, where he found a most picturesque fiord with an enormous glacier in the background; there were summits 2,500 feet high. The second journey was much more important; discoveries succeeded each other as if by enchantment. Mr. Payer penetrated into a sound or strait—Austria Sound—extending from south to north, and completely covered with small islands. This strait was prolonged as far as the latitude of 82° between two continuous masses of land. The eastern side was called Wilczek Land, the other Zichy Land. In going out of this pass, the explorer encountered a vast basin, from which emerged another land, named Prince Rudolph's Land. The extreme point attained by Payer and his companions was called Cape Fligely; it is situated nearly at the same distance from the pole as that reached by another route, in 1871, by the captain of the Polaris. There it was necessary to stop, on account of the crevasses and ruptures produced at this season in the

ice of the fiords. A strait, terminated by another land, lay open before the eyes of the travelers, whose prolongation, inflected to the east, could be followed even beyond the latitude of 83°. They named it Petermann's Land. What is, then, this new world that remains provisionally the *ultima Thule* of navigators? It is not, certainly, according to the report of Mr. Payer, a mass of insignificant islands; it is an entire regional system with a development comparable to the archipelago of Spitzbergen. Could it be the Land of Gillis, so much sought for in these later times?

The explorers, on returning from this long excursion, having had the good fortune to find their ship immovable in the same place, set out very soon for a third tour in a western direction. When fourteen miles from the Tegethoff, they made the ascent of a high mountain, from the top of which they could trace the general configuration of the country; the most elevated summit was 5,000 feet high. Finally, the moment came for thinking of a return home. On the 20th of May, 1874, they put themselves *en route*, but they were obliged to abandon the ship. All the members of the expedition were safe and sound, the mechanician alone having died. During ninety days, by the aid of sledges and boats, sometimes on the ice, sometimes on the open sea, the glorious Austrian pioneers wandered in these unknown regions, following always the direction of the compass to the south. In the beginning, the winds thwarted their progress to such a degree that after two whole months they were only eight marine miles distant from the ship. Their provisions also were nearly exhausted, when, on the 18th of August, they reached Nova Zembla. Six days after they embarked on the Russian steamer Nicholas, which carried them to Warsoe.

If the vicissitudes endured by this memorable expedition, the official report of which has not yet reached us, give the measure of the difficulties experienced in following in these regions a preconcerted plan, they show also that with coolness and constancy the resistance of polar chaos may be overcome. A day will come, doubtless, when the conditions of arctic life will be in some measure familiar to us, and the navigator will face less timidly its sombre horrors. Already he has succeeded in discovering his way through good and bad fortune into the variable windings of the great labyrinth; he has sounded the depths, studied the currents and counter-currents; he knows at what season such a channel is obstructed or free, and what routes the ice-fields driven to the south follow in their regular migrations. The principal features of this exceptional geography are, then, partially established; the essential point is, that the succession of polar voyages shall be no more interrupted. Too long have arctic explorations been made in a desultory and capricious fashion; audacity and courage have been lavishly used, but consecutive action has been wanting. Experiments, in order to acquire their full scientific value, must be

continuous, and it is therefore necessary that all nations should in turn relieve each other, according to their resources, in this attentive sentinelship of the outposts of the arctic world.

## SAVAGISM AND CIVILIZATION.[1]

By HUBERT H. B NCROFT.

THE obvious necessity of association as a primary condition of development leaves little to be said on that subject. To the manifestation of this soul of progress a body social is requisite, as, without an individual body, there can be no manifestation of an individual soul. This body social, like the body individual, is composed of numberless organs, each having its special functions to perform, each acting on the others, and all under the general government of the progressional idea. Civilization is not an individual attribute, and, though the atom, man, may be charged with stored energy, yet progress constitutes no part of individual nature; it is something that lies between men and not within them; it belongs to society and not to the individual; man, the molecule of society, isolate, is inert and forceless. The isolated man, as I have said, never can become cultivated, never can form a language, does not possess in its fullness the faculty of abstraction, nor can his mind enter the realm of higher thought. All those characteristics which distinguish mankind from animal-kind become almost inoperative. Without association, there is no speech, for speech is but the conductor of thought between two or more individuals; without words abstract thought cannot flow, for words, or some other form of expression, are the channels of thought, and with the absence of words the fountain of thought is, in a measure, sealed.

At the very threshold of progress social crystallization sets in; something there is in every man that draws him to other men. In the relationship of the sexes, this principle of human attraction reaches its height, where the husband and wife, as it were, coalesce, like the union of one drop of water with another, forming one globule. As unconsciously and as positively are men constrained to band together into societies as are particles forced to unite and form crystals. And herein is a law as palpable and as fixed as any law in Nature; a law which, if unfulfilled, would result in the extermination of the race. But the law of human attraction is not perfect, does not fulfill its purpose apart from the law of human repulsion, for, as we have seen, until war, and despotism, and superstition, and other dire evils come, there is no progress. Solitude is insupportable—even beasts will not live alone; and men are more dependent on each other than beasts. Solitude

[1] From vol. ii., "Native Races of the Pacific States.

carries with it a sense of inferiority and insufficiency; the faculties are stinted, lacking completeness, whereas volume is added to every individual faculty by union.

But association, simply, is not enough; nothing materially great can be accomplished without union and coöperation. It is only when aggregations of families intermingle with other aggregations, each contributing its quota of original knowledge to the other; when the individual gives up some portion of his individual will and property for the better protection of other rights and property; when he intrusts society with the vindication of his rights; when he depends upon the banded arm of the nation, and not alone upon his own arm for redress of grievances, that progress is truly made. And with union and coöperation comes the division of labor by which means each, in some special department, is enabled to excel. By fixing the mind wholly upon one thing, by constant repetition and practice, the father hands down his art to the son, who likewise improves it for his descendants. It is only by doing a new thing, or by doing an old thing better than it has ever been done before, that progress is made. Under the *régime* of universal mediocrity the nation does not advance; it is to the great men, great in things great or small, that progress is due; it is to the few who think, to the few who dare to face the infinite universe of things, and step, if need be, outside an old-time boundary, that the world owes most.

Originally implanted is the germ of intelligence, at the first but little more than brute instinct. This germ in unfolding undergoes a double process: it throws off its own intuitions, and receives in return those of another. By an interchange of ideas, the experiences of one are made known for the benefit of another, the inventions of one are added to the inventions of another; without intercommunication of ideas the intellect must lie dormant. Thus it is with individuals, and with societies it is the same. Acquisitions are eminently reciprocal. In society, wealth, art, literature, polity, and religion, act and react on each other; in science, a fusion of antagonistic hypotheses is sure to result in important developments. Before much progress can be made, there must be established a commerce between nations for the interchange of aggregated human experiences, so that the arts and industries acquired by each may become the property of all the rest, and thus knowledge become scattered by exchange, in place of each having to work out every problem for himself. Thus viewed, civilization is a partnership entered into for mutual improvement; a joint-stock operation, in which the product of every brain contributes to a general fund for the benefit of all. No one can add to his own store of knowledge without adding to the general store; every invention and discovery, however insignificant, is a contribution to civilization.

In savagism, union and coöperation are imperfectly displayed. The warriors of one tribe unite against the warriors of another; a

band will coöperate in pursuing a herd of buffalo; even one nation will sometimes unite with another nation against a third, but such combinations are temporary, and no sooner is the particular object accomplished than the confederation disbands, and every man is again his own master. The moment two or more persons unite for the accomplishment of some purpose which shall tend permanently to meliorate the condition of themselves and others, that moment progress begins. The wild beasts of the forest, acting in unison, were physically able to rise up and extirpate primitive man; but, could beasts in reality confederate and do this, such confederation of wild beasts could become civilized.

But why does primitive man desire to abandon his original state and set out upon an arduous, never-ending journey? Why does he wish to change his mild, paternal government, to relinquish his title to lands as broad as his arm can defend, with all therein contained, the common property of his people? Why does he wish to give up his wild freedom, his native independence, and place upon his limbs the fetters of a social and political despotism? He does not. The savage hates civilization as he hates his deadliest foe; its choicest benefits he hates more than the direst ills of his own unfettered life. He is driven to it—driven to it by extraneous influences, without his knowledge and against his will; he is driven to it by this Soul of Progress. It is here that this progressional phenomenon again appears outside of man and in direct opposition to the will of man; it is here that the principle of evil again comes in and stirs men up to the accomplishment of a higher destiny. By it Adam, the first of recorded savages, was driven from Eden, where otherwise he would have remained forever, and remained uncivilized. By it our ancestors were impelled to abandon their simple state, and organize more heterogeneous complex forms of social life. And it is a problem for each nation to work out for itself. Millions of money are vainly spent by benevolent people for proselyting purposes, when, if the first principles of civilization were understood, a far different course would be pursued.

Every civilization has its peculiarities, its idiosyncrasies. Two individuals attempting the same thing differ in the performance; so civilization evolving under incidental and extraneous causes takes an individuality in every instance. This is why civilizations will not coalesce; this is why the Spaniards could make the Aztecs accept their civilization only at the point of the sword. Development engendered by one set of phenomena will not suit the developments of other circumstances. The government, religion, and customs of one people will not fit another people any more than the coat of one person will suit the form of another. Thought runs in different channels; the happiness of one is not the happiness of another; development springs from inherent necessity, and one species cannot be engrafted on another.

Let us now examine the phenomena of government and religion in their application to the evolution of societies, and we shall better understand how the wheels of progress are first set in motion—and by religion I do not mean creed or credulity, but that natural *cultus* inherent in humanity, which is a very different thing. Government is early felt to be a need of society; the enforcement of laws which shall bring order out of social chaos; laws which shall restrain the vicious, protect the innocent, and punish the guilty; which shall act as a shield to inherent budding morality. But, before government, there must arise some influence which will band men together. An early evil to which civilization is indebted is war; the propensity of man —unhappily not yet entirely overcome—for killing his fellow-man.

The human race has not yet attained that state of homogeneous felicity which we sometimes imagine; upon the surface, we yet bear many of the relics of barbarism; under cover of manners, we hide still more. War is a barbarism which civilization only intensifies, as indeed civilization intensifies every barbarism which it does not eradicate or cover up. The right of every individual to act as his own avenger; trial by combat; justice dependent upon the passion or caprice of the judge or ruler, and not upon fixed law; hereditary feuds and migratory skirmishes; these and the like are that which moved our savage ancestors to like conduct, falls to, and, after a respectable civilized butchery of fifty or a hundred thousand men, ceases fighting, and returns, perhaps, to right and reason as a basis for the settlement of the difficulty. War, like other evils which have proved instrunents of good, should by this time have had its day, should have served its purpose. Standing armies, whose formation was one of the first and most important steps in association and partition of labor, are but the manifestation of a lingering necessity for the use of brute force in place of moral force in the settlement of national disputes. Surely, rational beings who retain the most irrational practices concerning the simplest principles of social life cannot boast of a very high order of what we are pleased to call civilization. Morality, commerce, literature, and industry, all that tends toward elevation of intellect, is directly opposed to the warlike spirit. As intellectual activity increases, the taste for war decreases, for an appeal to war in the settlement of difficulties is an appeal from the intellectual to the physical, from reason to brute force.

Despotism is an evil, but despotism is as essential to progress as any good. In some form despotism is an inseparable adjunct of war. An individual or an idea may be the despot; but, without cohesion, without a strong central power, real or imaginary, there can be no unity, and without unity no protracted warfare. In the first stages of government, despotism is as essential as in the last it is noxious. It holds society together when nothing else would hold it, and at a time when its very existence depends upon its being so held. And

not until a moral inherent strength arises sufficient to burst the fetters of despotism, is a people fit for a better or milder form of government; for not until this inherent power is manifest is there sufficient cohesive force in society to hold it together without being hooped by some such band as despotism. Besides thus cementing society, war generates many virtues, such as courage, discipline, obedience, chivalrous bearing, noble thought; and the virtues of war, as well as its vices, help to mould national character.

Slavery to the present day has its defenders, and from the first it has been a preventive of a worse evil—slaughter. Savages make slaves of their prisoners of war, and if they do not preserve them for slaves they kill them. The origin of the word, *servus*, from *servare*, to preserve, denotes humane thought rather than cruelty. Discipline is always necessary to development, and slavery is another form of savage discipline. Then, by systems of slavery, great works were accomplished, which, in the absence of arts and inventions, would not have been possible without slavery. And again, in early societies where leisure is so necessary to mental cultivation and so difficult to obtain, slavery, by promoting leisure, aids elevation and refinement. Slaves constitute a distinct class, devoted wholly to labor, thereby enabling another class to live without labor, or to labor with the intellect rather than with the hands.

Primordially, society was an aggregation of nomadic families, every head of a family having equal rights, and every individual such power and influence as he could acquire and maintain. In all the ordinary avocations of savage life this was sufficient; there was room for all, and the widest liberty was possessed by each. And in this happy state does mankind ever remain until forced out of it. In unity and coöperation alone can great things be accomplished; but men will not unite until forced to it. Now, in times of war—and with savages war is the rule and not the exception—some closer union is necessary to avoid extinction; for, other things being equal, the people who are most firmly united and most strongly ruled are sure to prevail in war. The idea of unity in order to be effectual must be embodied in a unit; some one must be made chief, and the others must obey, as in a band of wild beasts that follow the one most conspicuous for its prowess and cunning. But the military principle alone would never lay the foundation of a strong government, for with every cessation from hostilities there would be a corresponding relaxation of government.

Another necessity for government here arises, but which likewise is not the cause of government, for government springs from force and not from utility. These men do not want government, they do not want culture; how, then, is an arm to be found sufficiently strong to bridle their wild passions? In reason they are children, in passion, men; to restrain the strong passions of strong, non-reasoning men

requires a power; whence is this power to come? It is in the earlier stage of government that despotism assumes its most intense forms. The more passionate, and lawless, and cruel the people, the more completely do they submit to a passionate, lawless, and cruel prince; the more ungovernable their nature, the more slavish are they in their submission to government; the stronger the element to be governed, the stronger must be the government.

The primitive man, whoever or whatever that may be, lives in harmony with Nature; that is, he lives as other animals live, drawing his supplies immediately from the general storehouse of Nature. His food he plucks from a sheltering tree, or draws from a sparkling stream, or captures from a prolific forest. The remnants of his capture, unfit for food, supply his other wants; with the skin he clothes himself, and with the bones makes implements and points his weapons. In this there are no antagonisms, no opposing principles of good and evil; animals are killed not with a view of extermination, but through necessity, as animals kill animals in order to supply actual wants. But no sooner does the leaven of progress begin to work than war is declared between man and Nature. To make room for denser populations and increasing comforts, forests must be hewn down, their primeval inhabitants extirpated or domesticated, and the soil laid under more direct contribution. Union and coöperation spring up for purposes of protection and aggression, for the accomplishment of purposes beyond the capacity of the individual. Gradually manufactures and commerce increase; the products of one body of laborers are exchanged for the products of another, and thus the aggregate comforts produced are doubled to each. Absolute power is taken from the hands of the many and placed in the hands of one, who becomes the representative power of all. Men are no longer dependent upon the chase for a daily supply of food; even agriculture no longer is a necessity which each must follow for himself, for the intellectual products of one person or people may be exchanged for the agricultural products of another. With these changes of occupation new institutions spring up, new ideas originate, and new habits are formed. Human life ceases to be a purely material existence; another element finds exercise, the other part of man is permitted to grow. The energies of society now assume a different shape; hitherto the daily struggle was for daily necessities, now the accumulation of wealth constitutes the chief incentive to labor. Wealth becomes a power and absorbs all other powers. The possessor of unlimited wealth commands the products of every other man's labor.

But, in time, and to a certain extent, a class arises already possessed of wealth sufficient to satisfy even the demands of avarice, and something still better, some greater good is yet sought for. Money-getting gives way before intellectual cravings. The self-denials and labor necessary to the acquisition of wealth are abandoned for the en-

joyment of wealth already acquired and the acquisition of a yet higher good. Sensual pleasure yields, in a measure, to intellectual pleasure, the acquisition of money to the acquisition of learning.

Where brute intelligence is the order of the day, man requires no more governing than brutes, but when lands are divided, and the soil cultivated, when wealth begins to accumulate and commerce and industry to flourish, then protection and lawful punishment become necessary. Like the wild-horse, leave him free, and he will take care of himself; but catch him and curb him, and the wilder and stronger he is the stronger must be the curb until he is subdued and trained, and then he is guided by a light rein. The kind of government makes little difference, so that it be strong enough.

Granted that it is absolutely essential to the first step toward culture that society should be strongly governed, how is the first government to be accomplished; how is one member of a passionate, unbridled heterogeneous community to obtain dominion absolute over all the others? Here comes in another evil to the assistance of the former evils, all for future good—superstition. Never could physical force alone compress and hold the necessary power with which to burst the shell of savagism. The government is but a reflex of the governed. Not until one man is physically or intellectually stronger than ten thousand, will an independent people submit to a tyrannical government, or a humane people submit to a cruel government, or a people accustomed to free discussion to an intolerant priesthood.

At the outset, if man is to be governed at all, there must be no division of governmental force. The cause for fear arising from both the physical and the supernatural must be united in one individual. In the absence of the moral sentiment, the fear of legal and that of spiritual punishments are identical, for the spiritual is feared only as it works temporal or corporal evil. Freedom of thought at this stage is incompatible with progress, for thought without experience is dangerous, tending toward anarchy. Before men can govern themselves they must be subjected to the sternest discipline of government; and whether this government be just, or humane, or pleasant, is of small consequence, so that it be only strong enough. As with polity, so with morality and religion: conjointly with despotism there must be an arbitrary central church government, or moral anarchy is the inevitable consequence. At the outset it is not for man to rule, but to obey; it is not for savages, who are children in intellect, to think and reason, but to believe.

And thus we see how wonderfully man is provided with the essentials of growth. This tender germ of progress is preserved in hard shells and prickly coverings, which, when they have served their purpose, are thrown aside, as not only useless but detrimental to further development. We know not what will come hereafter, but up

to the present time a state of bondage appears to be the normal state of humanity—bondage, at first severe and irrational, then ever loosening, and expanding into a broader freedom. As mankind progresses, moral anarchy no more follows freedom of thought than does political anarchy follow freedom of action. In Germany, in England, and in America, wherever secular power has in any measure cut loose from ecclesiastical power and thrown religion back upon public sentiment for support, a moral as well as an intellectual advance has always followed. What the mild and persuasive teachings and lax discipline of the present epoch would have been to the Christians of the fourteenth century, the free and lax government of republican America would have been to republican Rome. Therefore, let us learn to look charitably upon the past, and not forget how much we owe to evils which we now so justly hate; while we rejoice at our release from the bigotry and fanaticism of mediæval times, let us not forget the debt which civilization owes to the tyrannies of Church and state.

Christianity, by its exalted unutilitarian morality and philanthropy, has greatly aided civilization. Indeed, so marked has been the effect in Europe, so great the contrast between Christianity and Islamism and the polytheistic creeds in general, that Churchmen claim civilization as the offspring of their religion. But religion and morality must not be confounded with civilization. All these and many other activities act and react on each other as proximate principles in the social organism, but they do not, any or all of them, constitute the life of the organism. Long before morality is religion, and long after morality, religion sends the pious debauchee to his knees. Religious culture is a great assistant to moral culture, as intellectual training promotes the industrial arts, but morality is no more religion than is industry intellect. When Christianity, as in Spain during the fourteenth century, joins itself to blind bigotry and stands up in deadly antagonism to liberty, then Christianity is a drag upon civilization: and therefore we may conclude that in so far as Christianity grafts on its code of pure morality the principle of intellectual freedom, in so far is civilization promoted by Christianity; but, when Christianity engenders superstition and persecution, civilization is retarded thereby.

Then Protestantism sets up a claim to the authorship of civilization, points to Spain and then to England, compares Italy and Switzerland, Catholic America and Puritan America, declares that the intellect can never attain superiority while under the dominion of the Church of Rome; in other words, that civilization is Protestantism. It is true that protestation against irrational dogmas, or any other action that tends toward the emancipation of the intellect, is a great step in advance; but religious belief has nothing whatever to do with intellectual culture. Religion, from its very nature, is beyond the limits of reason; it is emotional rather than intellectual, an instinct and not

an acquisition. Between reason and religion lies a domain of common ground upon which both may meet and join hands, but beyond the boundaries of which neither may pass. The moment the intellect attempts to penetrate the domain of the supernatural, all intellectuality vanishes, and emotion and imagination fill its place. There can be no real conflict between the two, for neither, by any possibility, can pass this neutral ground. Before the mind can receive Christianity, Mohammedanism, or any other creed, it must be ready to accept dogmas in the analysis of which human reason is powerless. Among the most brilliant intellects are found Protestants, Romanists, Unitarians, deists, and atheists; judging from the experiences of mankind in ages past, creeds and formulas, orthodoxy and heterodoxy, have no inherent power to advance or retard the intellect. Some claim, indeed, that strong doctrinal bias stifles thought, fosters superstition, and fetters the intellect; still, religious thought, in some form, is inseparable from the human mind, and it would be very difficult to prove that belief is more debasing than non-belief.

## THUNDER-SHOWERS.

By J. W. PHELPS.

THE thunder-shower of Southeastern Vermont generally comes from the southwest. To understand why it should take this course instead of any other, we must examine the topographical character of the country.

The chain of Green Mountains extends throughout the State from south to north, inclining some degrees to the east of north. It presents a barrier to the prevailing general current of southwest wind, and in summer condenses the vapor which that wind bears, thus forming piles of cumulus cloud over the higher summits, or most wooded districts. The deeper ravines, or river-beds, on the eastern slopes of the mountains, run to the southeast, and open out on the wider valley of the Connecticut River.

In order to convey a more definite idea of our theory, we will choose a certain locality which may serve the purpose of a diagram to our demonstration; and this locality shall be the region of West River. This river takes its rise among the forests near the summit of the Green Mountains, at a height of some 2,000 feet above the level of the sea, and, flowing southeasterly forty or fifty miles, empties into the Connecticut River about ten miles from the southern boundary of the State.

During a hot summer day the sides of the deep valley of this river reek with intense heat, and cause a flow of moist air upward toward

the summits of the mountain-ridge, from the valley of the Connecticut, and also from the sea. This moist air, meeting with the general current from the southwest, piles up an immense mass of cumulus cloud, of many square miles in extent. So long as the intense heat prevails, this cloud increases in size; grows black and blacker with its dense vapor, and casts a gloomy, lurid glare over the face of Nature, darker than that of any eclipse. The vapor, pushed up by the ascending currents of heated air, attains to a great height above the sea, where the temperature is very low. But finally, at that hour of the afternoon when the heat begins to decline, the accumulated vapors, no longer augmented or sustained by heated air from the valleys below, fall in rain.

The effect of large cold drops of water, or perhaps of ice, making altogether millions of tons in weight, falling from a great height into a deep, narrow valley, is, not only to beat down the air into that valley, but to chill the air there; and the cold air, seeking the lowest level, tends to rush down the valley, at first near the surface of the earth, but growing deeper and deeper, until the cloud itself is borne away on the swift-rushing air-freshet of its own making.

The land beginning to cool with the declining sun and the cooling rain, causes the southerly breeze to slacken and die away, and the storm-cloud rushes on unobstructedly down the West River and the Connecticut, deluging and fertilizing the fields along its course, while its quick lightning and oft-repeated claps of thunder flash and resound among the reverberating hills.

The cloud passes on, and often the sinking sun comes out from behind it; the late hushed and frightened birds gush forth with new song; myriad drops hang glittering on the spray; the green is flushed with a brighter, fresher hue, and the glowing rainbow smiles serenely from the dark, retiring, and still grumbling storm.

This storm is followed the next day by delightfully clear weather, with a cool, exhilarating breeze from the northwest; though this is not always the case, the cloud sometimes overspreading the sky, losing its motion, and leaving the air damp and murky.

The thunder-shower, as we have thus described it, though limited to a small district of country, may be regarded as the type of all similar showers that occur in mountainous regions everywhere. Numerous modifications, however, of local origin will occur, due to various causes; and it would be a highly-interesting and valuable study to ascertain these causes for every particular case.

Yet as to whether the moving force of the thunder-gust is limited wholly to the causes here given, may well admit of a question. It is not improbable that a cloud, from its great height, may penetrate a high upper current from the northwest, and that both this upper and the lower current may contribute to its rapid motion of translation. It is well that these thunder-showers are movable, instead of being

stationary, as they often are at sea, for otherwise summer rains would not be evenly distributed over the face of the country; and the land in some places would be subject to exceeding moisture, while in other places it would suffer from the drought.

A few days after the above was written, a violent thunder-gust closed a warm afternoon. It was on the 1st of August, 1873. The day had been hot and peculiarly oppressive, as is usually the case before a violent storm. Between four and six o'clock P. M., a thunder-shower came down the valley of West River, and corresponded in its general features with the description given above; but it exhibited in addition other features which were entirely peculiar. The lightning struck in five notably different places in the village of Brattleboro, which partly borders the valley of West River near where it disembogues into the Connecticut River, and these places, instead of being elevated points, were, in all cases except one, among some of the lower ones. And they were nearly all in the same straight line, about a half or three-fourths of a mile in length, and at a short distance from the Connecticut.

The strokes that fell upon these points followed each other in pretty rapid succession, and were accompanied by thunder that had a sound as if partly suppressed. It was neither loud nor jarring, as thunder sometimes is. The rain fell in floods, and was very copious. Its abundance, rendering the air seemingly nearly half water, doubtless occasioned the subdued sound of the thunder, and perhaps greatly reduced the force of the shocks; for in no case was any considerable damage done. An upper corner of a two-story house was shattered, two other buildings were slightly injured, and several trees were marked by narrow channels down their trunks or branches. Together with the first house struck, one of two fir-trees standing near was grooved at the same time, and some of the splinters were found in the chamber nearest the shattered corner, although the window-blinds were closed and fastened. These splinters must have been driven up between the slats of the blinds, which would seem to show that the stroke was upward instead of downward. A window-curtain near the corner was torn to shreds. In the lower room nearest the corner there were no effects of the shock observed except upon a gilt cornice which was marked at intervals by black perpendicular bars, the gilding there having been burned or melted. The intervals between these bars were in some cases very narrow, and at others very wide. Two persons sitting in this room perceived no effect from the shock.

At one moment during the storm the wind came from the north or northeast. This wind was probably highly charged with electricity, which, being added to the electricity of the northwest current, produced such an excess of the fluid as to result in the rapid and numerous discharges which took place. The most of these discharges apparently occurred along the line where the two currents of air met. The

more easterly current of air may have come over the shoulder of the mountain on the opposite bank of the Connecticut River, or it may have come down the valley of that river, and met the current coming down the West River in the village of Brattleboro.

With respect to the direction in which the lightning struck whether up or down, it is not improbable that in every stroke of electricity there are two opposing currents, one up and the other down. The splinters which adhere to the first tree struck show this, some remaining attached by the upper end, and others by the lower.

Beginning in the north, the first in order of the objects struck were a house and a tapering fir-tree near by, within about ten or fifteen feet, and towering considerably above the house. The house had no conductor. A hundred paces from there, in a southeasterly direction, a locust-tree was struck. It stood in a grove of locust, maple, poplar, butternut, fir, and other trees, within about thirty paces from a conductor upon a neighboring house, and not far from a tall Lombardy poplar. A hundred paces farther on, and at a lower level, one of the higher branches of a lofty elm was struck. At the distance of another hundred yards, in the same general direction, stands the Congregational church, and near it the Baptist church, both about 130 feet in height, and with conductors apparently in good condition. These churches were unharmed. About 400 paces from there, and at a still lower level, stands the fourth point struck, which is a three-story grist-mill; and, finally, some 300 yards or more farther on, and more to the westward, on a comparatively high point of land stands the dwelling-house, the fifth and last point known to have been struck —the last, we mean, in following the direction, and not in the order of time. The effect of the strokes at the two extreme points was severer than any of the others.

Reports from other quarters of the country show that the electrical condition of the atmosphere of New England on the 1st of August was considerably disturbed, thunder-showers occurring at many different places. When this is the case, it is reasonable to suppose that two showers, following down two neighboring valleys, may come together, and thus double the amount of electricity that might be possessed by one alone.

The question here occurs, "Is there any common origin between these thunder-showers and the northern lights?" Are they not each but a different means of restoring a disturbed electrical equilibrium? If this is the case, we might infer that, when thunder-showers are numerous and violent, the displays of the northern lights will be less frequent and less active, and *vice versa;* though there may be cases in which both become more than ordinarily active.

One of the discharges of electricity which we happened to observe during the shower was perhaps that one which fell upon the grist-mill. Amid the floods of descending rain, it looked like falling sparks of

fire. It was about 600 or 700 yards from where we sat, and the sound of the thunder was more like that of the rocket than that which usually accompanies electrical discharges. In fact, the cloud probably passed *through* the village rather than *over* it; and the discharges were necessarily short, close, and without prolonged reverberations, such as may occur when the stroke is high, partly in dry air, and several miles in length, the sound from which must reach the ear at different intervals of time, thus producing a continuous rolling noise.

We are here reminded of another thunder-shower, of peculiar features, which occurred in Brattleboro in November, 1860. It was on the day of the first election of Mr. Lincoln to the presidency. A pine-tree was rent into fragments by it, and a passer-by, a voter, on seeing the extraordinary havoc that had been made, the white, shining splinters lying scattered over the ground, in all sizes, from the smallest sliver up to strips long enough for rails, exclaimed in great excitement: "The thing is all up now; for the old 'Rail-Splitter' is around at his work!" Even thunder-showers are wrested by some men into a political significance!

The circumstances of the case, however, would appear to have been these: A dense cloud, borne upon a low southwest surface-current of wind, was passing across the deep valley of the West River, half a mile or so from its mouth, when it was probably struck by a cool, dry mountain-breeze flowing down the valley. This breeze imparted new electricity to the cloud, which, being thus overcharged, gave out its surplus in a sudden shock, which took effect upon a group of pines. Every drop of water of which the cloud was composed we may regard as a small Leyden jar, as it were, the united force of which proved sufficient to rend in pieces one of the pines in an instant of time. The tree was some seventy feet in height, two feet in diameter, and stood, not on the heights immediately under the cloud, but low down, within a few paces of the river. It was broken square off twenty or thirty feet from the top; and this top fell straight down and stood leaning against the shattered stump, showing that the trunk had been rent asunder so suddenly as to occasion no obstruction to its fall! There were but two discharges of electricity from this cloud; and soon afterward the weather cleared up from the northwest.

## THE AUSTRALIAN FEVER-TREE.[1]

DURING the present century, a great number of exotic plants and trees have been brought to Europe, or transplanted from their original habitat to other climes. In view of its usefulness, perhaps the blue-gum tree of Australia and Tasmania, belonging to the genus

[1] Translated from *Das Ausland*.

*Eucalyptus*, which includes upward of 150 species, holds the first place among these exotic plants. The *Eucalypti* belong to the natural order *Myrtaceæ*, and are indigenous almost exclusively to Australia and Tasmania. They are distinguished for a high development of the phenomenon known as heteromorphism—the same plant assuming a perfectly different habit at different stages of its growth. The species with which we are just now concerned, the *Eucalyptus globulus*, presents two very distinct forms: when the plant is young, the leathery leaves are opposite and sessile; this is a sort of larval state—the plant is not yet mature, and cannot produce flowers. But in the adult state the leaves are pedunculate and alternate, and then the plant flowers and bears fruit. This polymorphism, however, does not occur to the same extent in all species of the *Eucalyptus*, and it is almost altogether wanting in *E. cordata*.

The honor of having discovered the *Eucalyptus globulus* belongs to a French scientist, Labillardière, the botanist, who accompanied the Chevalier d'Entrecasteaux on his expedition in the year 1791, to search for the lost crew of La Pérouse. Labillardière's journal of May 12, 1792, at which date the expedition was in the Bay of Storms, Van Diemen's Land, indicates that even then this sagacious botanist anticipated the great value of this tree for ship-building purposes.

For a long time the *Eucalyptus globulus* was simply an object of curiosity, and many a botanic garden possessed it without any one knowing of the fact: thus M. Planchon assures us that he saw it in 1854 in the Paris Museum, under the name of *E. glauca*. In Tasmania the colonists well knew the value of their splendid blue-gum tree, and employed it for a thousand purposes. It became more generally diffused only after the colony of Victoria was founded, an event not yet forty years old. Two names are thenceforth specially connected with the history of the *Eucalyptus*, viz., those of Baron Ferdinand Müller, of Melbourne, the distinguished botanist, and of M. Ramel. From the Botanic Garden at Melbourne the *Eucalyptus* crossed the sea to Europe, Africa, and America, like many other plants from the same source which have been acclimated in foreign lands.

Justly, as we think, M. Planchon observes that the term acclimation is apt to suggest erroneous notions, and that it is based upon a profound misconception of the true nature of plants—their temperament, so to say. Plants are imported and become naturalized, if you please; but this adaptation in all cases takes place very slowly, gradually, by selection of individuals from successive generations, by the production of races or local varieties which experience shows to be the best fitted to adapt themselves to the special conditions of climate and environment in which they exist. Though there are many grades of naturalization, they can all be reduced to two categories, viz., that of plants which accompany man and domestic animals, and which never separate from them; and, secondly, those plants which, in order

to thrive in a foreign land, whether in the wild or the domesticated state, imperatively require care from the hand of man.

To the latter category belongs, as yet, the *Eucalyptus globulus*, at least in the extreme south of Europe and in Northern Africa. The tree has been introduced in those regions, cultivated there on a large scale, but not yet naturalized. But, further, we find it at the Cape of Good Hope, in the La Plata states, in California, Cuba, etc. It was brought to Algeria in 1854, but we date its introduction there more properly from the year 1861, when M. Ramel, whose name we have already mentioned, brought the seed thither from Melbourne. Soon a genuine *Eucalyptus furore* broke out: every one desired to own the beautiful tree, and they were planted in Algeria by the thousand. Like the agave and the opuntia, the *Eucalyptus* seems as though expressly intended for Algeria; it is not so much at home on the northern shores of the Mediterranean. In southern France, in Languedoc and Provence, after many years' experience, M. Planchon holds out no promise that the tree will ever increase so as to cover the land with forest, or dry up swamps. In Eastern Provence, the *Eucalyptus* has existed since 1858, and, between Cannes and Monaco, it thrives amid the gray-green olives and the Italian pines. Here the *Eucalyptus* is naturalized just as in Algeria. The well-known Princess Dora d'Istria is showing great zeal in promoting the naturalization of this useful tree on both shores of the Mediterranean. At Rome they are now making experiments with the *Eucalyptus globulus*. At the malaria-infested monastery, Tre Fontane, near Rome, one of the most insalubrious localities of the Campagna, the writer of these lines saw in April, 1874, young *Eucalyptus* plantations tended by French Trappists. On the other hand, the young trees planted in 1858, in the Botanic Garden of Pampelmousses, on the island of Mauritius, perished in 1868. The tree could not withstand the violent storms to which that island is exposed.

In their native soil several species of *Eucalyptus* attain an extraordinary height. Baron Ferdinand von Müller tells of a *Eucalyptus amygdalina* which, by its height (152 metres), might overshadow the Pyramid of Cheops, the loftiest structure erected by man. The *Eucalyptus globulus* does not, it is true, attain such extraordinary dimensions, but yet its trunk can yield boards of enormous breadth. The timber being distinguished for solidity, toughness, and durability, is in request for ships' keels. It possesses certain resinous properties which preserve it from decay, whether underground or in water. The growth of the tree is extremely rapid—a rare circumstance with trees having wood of firm texture. Especially in its early years does the tree grow with astonishing rapidity; but it goes on growing in height till about its eightieth year. After that time the stem, which is usually very erect, increases only in diameter. The stem rises to a great height before it sends out branches, and its summit is scantily crowned with

foliage. "Fever-tree" is the name given at Valencia, Spain, to the eucalyptus-trees planted there in 1860. The title is due to the fever-dispelling properties which the *Eucalyptus* possesses. In point of fact, those regions where this beautiful tree is indigenous, and where it grows into forests, enjoy a very healthy climate. But, further, we have evidence that the planting of the *Eucalyptus* in marshy localities counteracts paludal fever. This has been shown by experience at the Cape, in the provinces of Cadiz, Seville, Cordova, Valencia, and Barcelona; in Corsica, and in Algeria. At Pardock, distant a few miles from the city of Algiers, there was a farm on the banks of the Hamyse which was noted for its fevers, so that people died there "like flies," so deadly was the atmosphere. In the spring of the year 1867, 1,300 eucalyptus-trees were planted there, and even in July of the same year—the month in which the fever is wont to be most virulent—there was not a single case of disease, although the trees were then only nine feet in height; and the place has been free from fever ever since. In the vicinity of Constantine, the farm Ben Machydlin was in the like bad repute; all around it were swamps that never were dry, not even in the hottest summers. Still, in five years this great morass was completely dried by the planting of 14,000 eucalyptus-trees, and the health of the inhabitants has ever since been excellent. So Gue, near Constantine, once a place infested by fever, is now salubrious and free from fever, having been surrounded with a plantation of *Eucalypti*. The Abbé Felix Charmetan states that, at Maison Carrée, near Harrasch, the eucalyptus-plantations have rendered the use of quinine unnecessary. Finally, the same is said in regard to Cuba and Mexico. In the department of Var, Southern France, there is a railway-station situate in a very insalubrious locality. The place has become perfectly healthy since forty eucalyptus-trees were planted there.

These facts justify the hope that the *Eucalyptus* will yet free the Roman Campagna of its fever, and Garibaldi, who is now agitating the question of restoring to cultivation that wilderness, would perhaps do well to visit the Trappists of Tre Fontane, and acquaint them with his intentions.

The *Eucalyptus* has, in sundry instances, proved to be advantageous as a remedy for periodic fevers, and it furthermore possesses disinfecting as well as antiseptic properties. Distillation of the leaves and other parts of the tree produces an essential oil, the physiological effects of which upon both the sick and the well have been carefully studied by Dr. Gimbert.

The hardiness of the *Eucalyptus globulus* is still in dispute. It is asserted that the tree cannot endure the severity of our northern winters, and that it can hardly thrive save in a climate like that of its native habitat—Australia and Tasmania. In support of this view we

have the observations of many gardeners in the British Isles, who assert that the tree "cannot resist severe frost, and consequently does not last many years." "I have frequently seen," writes one, "young trees, ten, twenty, and even thirty feet high, in the Channel Islands, growing vigorously during a period of three, four, or more years in sheltered situations, but, on the appearance of severe frosts, killed to the ground." On the other hand, various correspondents of the *Gardener's Chronicle* write that, during the severe cold of last winter, the *Eucalyptus* was uninjured in the island of Anglesea, and in the west and south of Ireland.

## THE SUN'S WORK.

THAT the Sun causes a saving of fire and candle was known to all antiquity from the day fire and candle were first invented; and that was nearly all they knew about him. Nothing more was known for ages. It was only yesterday that he set up the business of sketching portraits and no matter what. He did it so cheaply and so correctly as to rob poor miniature-painters of their bread; and then came another halt, though only a short one, in our knowledge of what the Sun can do. But now, the more we know about him, the more grounds do we find for surmising that he is a marvelous servant—perhaps master—of all work.

Among the *cartes de visite* with which the sun presents us, are now to be included his own, in various moods of temper and expression. Thanks to photography and spectral analysis, the solar phenomena are daily fixed on paper and submitted to the inspection of an inquiring public. They thus escape from the narrow and not very accessible domain of observatories, and enter the grand current of publicity. Both in America and in England, numerous specimens of astronomical photography are offered for sale. First as to merit stand the admirable photographs of the moon published by Mr. Lewis Rutherfurd; and those of the Sun's disk, which present the spots, the facules, and the brilliant marblings of his surface with as much clearness and as striking an effect as the very best telescope; and also those of the solar spectrum, whose stripes have been self-registered with a fidelity which leaves no room for cavil. The low price of the "Annuaire of the Bureau des Longitudes"—where M. Faye has published the essay from which this paper has derived its facts—does not allow it to give actual photographs; it is obliged to be content with carefully executed engravings from originals supplied by the Observatory of Wilna.

Cosmic meteorology, that is the meteorology of the universe con-

sidered as a whole, is a new and somewhat ambitious term which is striving to obtain a footing in science; and, as the Sun evidently plays one of the leading parts in it, we naturally ask what is his line of action and what he does. And our inquiries are advancing not only under the guidance of more extended views, but by the help of bold and patient research already resolutely carried out. Astronomers long concentrated (with great success) their talents within the limits of our solar system, ignoring the rest of the universe, as if it were necessarily excluded from the domain of positive knowledge. The first step taken out of those narrow bounds was Fourier's conception of the important influence of the temperature of interstellar space, due to the heat given out by the stars.

Fourier's notion has recently been amplified by the account which has been taken of the chemical radiations that reach us from the same source. On beholding tiny stars imprint their image on the photographer's sensitive plate in less time than the Moon herself, we cannot help believing that the actinic power of these myriads of distant strangers—outsiders to our system though they be—must exert some kind of influence upon our world.

Do not meteorites and shooting-stars put us in daily relation with cosmic materials, which reach us straight from the depths of space, or which have not formed part of our system for more than a few centuries? Moreover (and it is another view of the question), within our system itself we observe phenomena which we cannot attribute to the ordinary action of solar heat, and which, nevertheless, are evidently connected with the sun. From which we draw the obvious conclusion that the Sun has active powers of which we are ignorant; that the same is the case, perhaps, with the planets themselves; in short, that we have yet to investigate a multitude of relations between the earth and other heavenly bodies, of whatever kind. We naturally hope to prove the mutual influence of the stars, more particularly in respect to terrestrial magnetism and the electricity of our globe—as a striking instance of which may be cited M. Becquerel's happy hypothesis of the solar origin of atmospherical electricity. The only fear is, lest, once embarked in this line of speculation, we should be tempted to carry it too far.

There is less danger of error in studying certain actions of the sun which, though still mysterious, are constant and undeniable. By fixing our attention on the sun himself, the source of all energy here below, we run less risk of being led astray. For example: do we find, in known solar phenomena, any reason to believe that the Sun has other means of action besides his attraction, his heat, and his light? The answer, "Yes," is ready. The Sun possesses and exercises a plainly-marked repulsive power, of which meteorology has hitherto taken no account, although our atmosphere must experience its effects. Of the existence of this special force no doubt is entertained by astronomers

who have studied the astounding configuration of comets. Olbers believed in a repulsive action; Bessel in a polar force; Bond, recently, on the occasion of Donati's comet, so deeply studied in America, deduced from it a simply repulsive force, and M. Roche, of Montpellier, adopted the same idea.

At first sight, it seems very strange to find the same body producing at once two opposite actions, an attraction and a repulsion. Nevertheless, if these two forces act according to different laws, they may coexist without being confounded in one single result, and may produce perfectly distinct effects. It is thus that the Newtonian attraction, which subsists between the molecules of every individual body, is by no means confounded or incorporated with the electrical or magnetic phenomena of which that same body may be the seat, or with the repulsive actions due to heat.

Now, although the most delicate observation of the celestial movements (planets and satellites) has hitherto revealed attraction alone, it is impossible at the present day to deny that the striking phenomena displayed by comets betray the existence of a quite different force, capable of driving to a distance, with incredible velocity, the most loosely attached and most attenuated particles of the matter composing them.

When a comet, arriving from the depths of the firmament, approaches the Sun, describing round him an immense ellipse almost parabolic in form, it appears to us as a spherical nebulosity more or less condensed toward its centre—that is, in the shape assumed by a body whose particles have freely taken their places under the sole influence of their mutual attractions. The sun's attraction (which at that great distance is virtually equal for all those particles), does no more than draw the comet toward it, as a whole, and in a lump as it were, without affecting its shape. But, when the distance diminishes, the parts of this sphere nearest the sun are drawn with greater force than the more distant parts diametrically opposite, and the primitive spherical figure can no longer subsist. The comet tends to grow longer and longer in the direction of the ideal line which connects it with the sun, absolutely in the same way as our globe, in its liquid portion, is drawn out into two opposite swellings familiarly known as ocean-tides. Nay, more: if the bond of mutual attraction which holds the particles of the comet together is not sufficiently powerful, it will give way; under the sun's attractive action, the comet will be decomposed, scattering its materials along its orbit, gradually transforming itself into a sort of very elongated ring of dust, like those which Schiaperelli's discovery shows to be the cause of shooting-stars when the earth happens to traverse them.

This is all that can result from the sun's attraction. But matters do not end here; and comets which have resisted for ages the destructive agency of attraction, now present quite different phenomena,

which, consequently, can no longer be attributed to that force. We see them drawn out and lengthened in the direction of the above-mentioned ideal line; but the matter which gushed forth (so to speak) on the sunshiny side is quickly arrested and driven back, while on the opposite side the matter rushes out, without meeting an obstacle, with an impetuosity of which no earthly phenomenon can give an idea. In a few days there is thus produced a tail diametrically opposite to the sun; and this tail may stretch before our eyes to a length of ten, twenty, thirty, or even sixty millions of leagues.

So great, in truth, is the complexity of cosmical phenomena, even when connected with unknown forces, that we might despair of success were we not offered a resource of which astronomical science has often availed itself—namely, the comparison of phenomena which occur at the same periodical intervals. Long before the discovery of universal gravitation, it was easy to see that the tides depended on the moon, since the periodicity is identical for the oscillations of the sea and the movements of our satellite. In like manner, the most complicated phenomena of meteorology, if they manifest a periodical character and their course agrees with the period of other strange phenomena, betray thereby their connection, in some way or other, with the latter.

Let us take, as an illustration, the variations of the dip of the magnetic needle. Every day, that needle, suspended freely, deviates in the morning from the position of equilibrium, and every day returns to it in the evening, after an excursion of variable extent. These regular movements evidently depend on the presence of the Sun above the horizon of any given spot; they also depend on its geographical situation, for they increase with the latitude on one hemisphere, and change their direction in passing from one hemisphere to the other. They are not due to a magnetic action proper to the sun; for, even supposing it to exist, the Sun, in consequence of his enormous distance, would be incapable of exercising a directing influence on a magnetic needle; but they result from some unknown action exerted on the electricity of the globe, and on the currents resulting from it—currents which themselves react on the direction of the needle, and often seriously disturb its movements.

How are we to give a precise account of this mode of action? In the midst of so many unknown details, how are we to lay hold of those which really require our attention? Observation, only, aided by this special form of empiricism—pointed out by M. Faye in his "Notice," and here attempted to be described—can help us in the matter. The diurnal variations of the needle have been noted for nearly a century past; it is remarked that they are not constant from one year to another; that they present maxima and minima, epochs of greatest and least activity; that these maxima occur every eleventh year. The phenomenon is periodical, and its period is eleven years.

Does there exist in the Sun (for it would evidently be useless to seek elsewhere) a phenomenon with a similar period? If such is the case, we shall perhaps have laid our hand on a simple relation of cause and effect. At all events, it will be a valuable hint and a sort of first indication of the track we ought to follow. Now, the spots on the Sun observe a precisely analogous period. Every eleven years they offer a strongly-marked maximum of frequency, followed, after an interval of several years, by a minimum, during which the Sun appears every day without a single accident or blemish on his brilliant surface. We are led, therefore, to investigate the case more closely.

More closely, in fact, we ought to look; for the coincidence may not be strictly exact. In that case, the present agreement of the two phenomena would be purely accidental; at the close of several periods it would disappear, and we should have been the dupes of a mere illusion. But M. Faye quotes a comparative table of the periods of the solar spots and of terrestrial magnetism, drawn up by M. Wolf, of Zurich, from which it appears that even the slight anomalies that occur, in respect to the average period of one of these phenomena, are faithfully reproduced by the other. This remarkable coincidence was almost simultaneously pointed out by General Sabine, Monsieur R. Wolf, of Zurich, and Monsieur Gautier, of Geneva.

Thus the spots on the Sun—those amplified whirlwinds which, by digging hollows in his surface here and there, introduce into his brilliant shell masses (more or less considerable) of the cooler hydrogen which envelops it—exercise on magnetism a daily action which is perfectly sensible to us. The problem of these mysterious variations, thus circumscribed, becomes henceforth more accessible.

True, the problem is not solved by that solitary circumstance. The advent of the spots determines two influences: first, they sensibly reduce the extent of the active surface of the Sun, and consequently of his radiations; secondly, they cause in the chromosphere, and far above it, gigantic hydrogenous eruptions, whose effects we are unable to appreciate. But that is precisely the point on which we have to concentrate our means of investigation; it is exactly there that Science may hope to seize the word of the enigma.

And, since there is an enigma, we are all the more strongly urged to solve it, because the daily variations of the magnetic needle are not alone in being affected by the variations of the photosphere. The same mode of reasoning connects them with the appearance of auroræ boreales. Here we are on familiar ground, discussing a phenomenon visible to and admired by all. Already Arago had remarked a sort of connection between the apparitions of the northern lights and disturbances of the magnetic needle. The concomitance was singular. And now we find that those auroræ present, exactly like the variations of the magnetic dip, a period agreeing with that of the

sun-spots. A table drawn up by Mr. Loomis, without suspecting their remarkable coincidence, establishes it beyond a doubt.

Nor is this all. Once started on the road, empiric science follows the clew of its deductions. After the auroræ boreales come the cirri, the mare's-tail clouds, of a peculiar form, which float very high in the atmosphere, entirely formed of extremely minute spicules of ice. These have an intimate connection with auroræ boreales, and seem to be in some sort the atmospheric substratum or stage of all their manifestations. It is now endeavored to ascertain whether there does not also exist some relation between the frequency of those clouds and that of the solar spots. In short, there is now, in meteorology, an emulation of discoveries based on these analogies of periods or on the influence of the solar rotation. And we are bound to call attention to this novel tendency of astronomical research, which Donati, a few days before his death, characterized as the advent of a cosmic meteorology—that is, as already stated, of a meteorology in which account should be taken of the multiple reactions of the stars on each other, without limiting those reactions to the habitual forces of attraction and heat.

To this cosmic meteorology evidently belongs Fourier's notion of a combined action which the universe (leaving the Sun out of the question) exercises upon us by its calorific radiations. If the Sun were to go out, the temperature of the solar system would not sink indefinitely—or rather it would not fall to the absolute zero (273° Centigrade)—but would stop at a certain point, which Fourier estimated at 62° Centigrade below the freezing-point of water. The importance of this temperature must not be estimated by the abnormal figures which measure it: for it appears to be a condition of our very existence, by imposing a limit to the lowerings of temperature produced by the long nocturnal radiation of polar regions. It must be added that Messers. Huggins and Stone have recently justified this bold conception by measuring the heat radiation of several bright stars which they find superior to that of the Moon herself—who ought, one would at first sight believe, to reflect so fair a share of solar heat.

This, then, is the Sun's work. He controls the compass; he marshals the northern lights; he permits or forbids ice-crystal clouds to hover high in the atmosphere; besides performing other offices which we may not at present even suspect. And thus a deeper study of his nature and action tends to modify notably the face of Science, to enlarge our views, and to demonstrate more clearly by what multitudinous links terrestrial existences are connected with the entire universe.—*All the Year Round.*

# THE ENDOWMENT OF SCIENTIFIC RESEARCH.

By RICHARD A. PROCTOR.

## I.

THERE are questions admitting, when viewed in the abstract, of but one answer, which yet, considered in their practical aspect, present difficulties that are almost, if not wholly, insuperable. Among them must be reckoned one which before long will attract, as it pre-eminently deserves, the attention of the nation—the question whether it is desirable that the investigation of natural facts, regarded as a vocation, should be publicly endowed.

When I say that but one answer can be given to this question, viewed in the abstract, I draw two distinctions: 1. I consider only the question whether science deserves public recognition; and, 2. I suppose the question submitted only to those who can properly consider it—those, namely, who are at least acquainted with scientific methods, if not versed in scientific subjects. To many it may probably appear a matter of small importance whether science advance or stand still. The general public scarcely recognizes the position which Science has already taken, still less the position she is about to take. Men do not perceive that the gradual advance of science must modify the condition of the human race, not in material matters alone, but even more by its influence on the feelings and emotions. In the course of time—and of no very long time, if future progress accords with present promise—the motives now most potent among men will yield to worthier influences, arising from clearer insight into physical, physiological, and psychological laws. Science, using the word in its best sense, has now a limited extension; but it is as a leaven in the midst, by which the whole lump will be leavened. In the mean time, men attend, as of yore, to matters which they regard as far more important than the growth and spread of knowledge—matters which have made up the history of the nations during many centuries, but have tended little to the advancement of mankind. Political plotting and counter-plotting, within each nation and among different nations; the preparation and employment of armaments thus rendered necessary; legislation by which class distinctions are strengthened and class dislikes intensified; the working out of social arrangements barbaric in origin and absurd in most of their developments; controversies over religious questions more or less closely associated with primeval superstitions—these and such as these are the occupations to which the world mainly devotes the energies not absorbed in the general struggle for existence. Science, in the mean while, conscious of its strength and certain of its future, can afford to wait. "Its development," as

Tyndall has well said, "is as necessary and irresistible as the motion of the tides or the flowing of the Gulf Stream. It is a phase of the energy of Nature, and, as such, is sure in due time to compel the recognition of those who now decry its influence and discourage its advance."

That science is worthy of endowment will be admitted by every one competent to form an opinion. Yet I would remark, at the outset, that the reasons sometimes advanced by students of science in support of this proposition are not of the worthiest, though they may be those best calculated to secure the alliance of the unscientific. Even Tyndall has spoken of science as though its chief value resided in its quality as "a source of individual and national might;" and many have dwelt on its value as a means of adding to material wealth. It would be affectation to contemn such considerations, but assuredly they do not present the noblest qualities of science, the chief good which science is competent to work. It is as a potent means of culture that science is worthiest of recognition. The material gain derived from scientific research has no doubt been great; but it has been incalculably surpassed in value by the change which science has worked and is working in the minds of men. It is, indeed, precisely in this respect that unscientific persons most completely misapprehend the work which science is doing. They attach special value to those things which science is silently but certainly displacing. They are pained by the light which science is pouring on objects that had seemed venerable so long as their defects had been veiled under the gloom of ignorance. They are appalled when science would teach them to displace all false loyalties by the noblest loyalty of all—loyalty to the truth. But the student of science can deal with such errors as he would deal with errors of observation or with untrustworthy experiments. He is not concerned to war against them. To be angry with them would be as unscientific as to be angry with gravitation. The true teachings of science will be recognized in due time—with results easily foretold. It was predicted that the religion of mercy would bring, not peace, but a sword; the seemingly stern religion of truth will bring, not a sword, but peace into the world. To recognize the universal reign of law is to perceive the futility of lawlessness, no matter under what high or even sacred names disguised. The culture of man through the study of truth is the work of science in the future. And scientific research derives incalculably greater value from the fact that it affords material for scientific culture than because it may add to national or individual power, or become a means of increasing our store of material wealth. Even the benefits derived from those departments of science which tend most to ameliorate the condition of the masses, great though these benefits unquestionably are, must be esteemed small by comparison with those which will hereafter be derived from science as a means of mental and moral culture.

I am careful to deal with this point at the outset, because it removes any difficulty which might arise from the question of the relative value, commercial or otherwise, of various departments of science, or of different discoveries in any given department. Regarding science as a means of culture, all scientific discoveries are valuable, though not all equally so. Some which are least useful in the ordinary sense are preëminently valuable in this respect. To take an example from astronomy: Although it would be difficult to say that any scientific discovery cannot *possibly* confer material benefit on the human race, I suppose no discovery could promise less in this way than Sir W. Herschel's recognition of wide-spreading nebulosity in certain regions of the heavens. Follow out, however, the train of thought that this discovery suggests, and it will be found that the discovery has had an influence by no means insignificant in dispossessing ideas which have wrought in their day incalculable mischief. As Draper has well said, in his "Conflict between Religion and Science," the nebular hypothesis rests primarily on this discovery; and the recognition of the truth of that hypothesis compels us "to extend our views of the dominion of law, and to recognize its agency in the creation as well as in the conservation of the innumerable orbs that throng the universe." Is this recognition of the reign of law barren? Let the reader of the history of the last five hundred years consider only what would have been the influence, throughout that interval, of a clearly-defined and widely-spread belief in the dominion of law, and he will neither hesitate how to reply, nor question the value of such a belief in future ages. The doctrine of the universality of law, once understood by the masses, cannot but prove a safeguard against excesses such as have been and continue to be committed in the name of religion—a safeguard even against the very existence of the superstitions to which such excesses are due. The belief in universal law, regarded by many in these days as a rock ahead, will be one day recognized as a breakwater against seas which have been heavy and may be heavy yet again.

In this way of estimating the value of science, and therefore the importance of scientific research, we may find an answer to the difficulty which presents itself when we consider the actual position of scientific workers—the fact, namely, that the search for scientific truth affords the worker no direct means of maintenance. A man may give many years of labor to discover some great law of Nature, or some important scientific fact, and when he has achieved success he may find that his discovery is his sole reward. This, indeed, may be the sole reward he has wrought for. Indeed, I think the true student of science would wish to dissociate from his special subject of research all idea of material reward. Yet it is as true of the minister and interpreter of Nature as of the minister and interpreter of religion, that "the laborer is worthy of his hire."

If the scientific worker is wealthy, and therefore presumably has abundant leisure, he will seek no material reward (precisely as those scions of wealthy families who enter the service of religion seek, I suppose, no payment for their ministries). But it has been well remarked that "there is unfortunately no necessary connection between wisdom and the inheritance of riches; and consequently it is always within the bounds of possibility that a man of property may subsidize in his own person, not knowledge, but error, a mischievous crotchet, or a perfectly fruitless and impossible inquiry, and may employ the contents of a bottomless purse in compelling the attention of the world to it. . . . There is also no guarantee in the case of a private person . . . . that the investigator is sufficiently furnished with the preliminary knowledge or training to make his remarks fruitful. In short, work supported by private means is very likely to be *amateur* work, or *duplicate* work." [1]

Every man who desires to make researches in science, and who is not possessed of private means sufficient, not only for his support, but to provide for the expenses of his researches (in some cases necessarily heavy), must either select an occupation which will provide the required means without taking him from his special subject of research, or must simply withdraw from the scientific work he had proposed to undertake. The alternative may present itself to him at the outset of his career; or gradually as his scientific work becomes more and more difficult, through the pressure of other duties; or sudden losses may bring the alternative home to him, after original scientific work has already commenced. Of the third case I shall say little in what follows, as it is probably unusual, and, when it occurs, must, for the most part, lead to entire withdrawal from scientific work. In whatever way the alternative may present itself, the student of science who determines to continue his investigations is not troubled by any great difficulty in selecting the occupation which he will combine with the pursuit of knowledge. For the available occupations are few indeed.

There are some salaried posts to which light scientific duties (chiefly educational) are attached. But these are not commonly, I believe,[2] to be obtained at the beginning of a scientific life, nor readily by those who find the gradual pressure of expenses interfering with scientific labors. They are not, indeed, necessarily awarded to science-workers at all; nor, when so held, have they invariably been found to encourage steady work in science. I am speaking, be it understood, of offices, professorial or otherwise, where the special duties

[1] *Fortnightly Review* for October, 1874: Mr. Appleton on the "Endowment of Research."

[2] In speaking about salaried and official posts, I rely on information derived from others, my own avocations not having led me at any time, or being at all likely hereafter to lead me, to seek direct information on such matters.

are light, and where therefore it is to be understood that those appointed are expected to devote themselves to original scientific research. Where heavy duties are attached to offices of this kind, scientific research is necessarily checked. We have an example of this in some professorships in America, the holders of which are compelled to devote so much time to the routine of class-work, that they are barely able even to keep themselves abreast of the scientific work of the day. But in Great Britain there are several offices which would seem to have been specially designed to afford means and leisure for original scientific research. Yet, if we consider the total number of men holding such offices, their abilities, and their opportunities, we must admit that the results they achieve are not collectively so great as might be expected. In certain instances, indeed, it would almost seem as though election to these well-paid offices had been the sole end and aim of work seemingly undertaken from pure love of science, so thoroughly has original research ceased, or become unfruitful, when the desired post has been secured. We must not close our eyes to this fact, nor suffer the zeal and energy of the few to blind us to the negligence of many who hold such offices. The point is one which would have to be carefully considered in any scheme for the endowment of research. If physical research is ever to be freely endowed, some plan would have to be adopted to obtain honest and faithful workers—not men who would regard scientific discoveries only as a means of securing salaried idleness.

But most of the salaried offices at present open to science-workers have heavy, or at least wearisome, duties attached to them. A professor of science who has to attend daily in the class-room, to consider how to make clear to dull minds matters altogether familiar to him, to prepare or emend text-books, and to take also his share in the control of large bodies of young men, cannot possibly give any great portion of his energies to original research. "In a few cases," as Mr. Appleton remarks, in the paper from which I have already quoted, "a *little* research can be done; in the majority of probably the best instances, all that is possible to the teacher is to keep himself abreast of that which is being accomplished by others; in too many, it is to be feared that even this is rendered impracticable by the exigencies of continual publicity." This publicity, indeed, must be of all others the most annoying hindrance to scientific research. I say *must be*, because my own course of life (except for occasional short intervals, at my own choice and under my own control) has been so completely that of the recluse, that I can only imagine the effects of a continued slavery to "the exigencies of publicity." Yet I have seen enough to feel assured that what Mr. Appleton describes as "the available store of nervous power" must be drawn upon far too largely, in most instances, to leave much energy for original research.

There remains, so far as the association of science and education is

concerned, what may be called the literature of science. And here, I must confess, I do not share the opinion which has been expressed by some, that the purely scientific qualities must suffer in proportion as the expositional power is exercised. The habit of exposition developed by an educational calling may, indeed, as Mr. Appleton has remarked, "have a tendency to bring into prominence the element of form and phrase rather than that of substance," *if*, by an educational calling, we understand the routine of the class-room. Going continually over the same ground, the class-teacher must of necessity be unable to advance. But so far as the literature of science is concerned, even though the most elementary and popular forms of scientific literature be in question, this need not happen. The assertion that "the growth of the popular and rhetorical element—*die phrase in der Wissenschaft*—is almost always a symptom that the work of investigation is standing still," is not justified by facts. The most fruitful of our scientific workers are also those who have succeeded best in scientific literature. Sir J. Herschel, Lyell, Darwin, Huxley, Tyndall, Spencer, Grove, Lubbock, Tylor, Owen, Carpenter, Wallace: these are some among the men who have done most for the literature of science. They have not been checked in original research by the time devoted to such literature. Nay, I believe that every one of them would tell us that the hours so employed were among those most fruitful in suggestive thought, and therefore (by no means indirectly) in the advancement of original research. It appears to me—and here I speak to some degree from my own experience—that to write out a clear account of the results obtained during scientific work is so useful an exercise, that, apart from all question of the utility of popular treatises on science, the scientific worker should adopt the practice for his own sake. I feel sure that certain crude theories, which have been maintained by some who pride themselves most on avoiding the popular and rhetorical element, would have been abandoned had they been submitted to this process.[1] For my own part, however, I attach so much importance to the extension of sound scientific knowledge—so much more importance to this, I will even say, than to the results of the scientific researches of any man, or even of any body of men—that I regard as most earnestly to be deprecated all attempts to deprive our people of the literary services of those alone who can write effec-

[1] Prof. Tyndall was, on one occasion, berated and underrated for one of his most useful treatises, by an opponent of rhetoric, a skillful mathematician, who had advanced a theory about comets which would have crumbled into nothing under the test of popularization. To popularize a theory one must present it clearly, and therefore one must conceive it clearly. (Boileau said well, "Ce que l'on conçoit bien s'énonce clairement.") But, to conceive a theory clearly, one must view it in so many aspects that, if it has any flaws, they are almost certain to be recognized. I believe every successful popularizer of science must have had this experience—that a theory which had seemed satisfactory under ordinary scientific tests has been found wanting when he has endeavored not only to describe the theory itself clearly, but also the arguments for and against it.

tively or satisfactorily about science—the scientific workers themselves. Too long what has been called the popularization of science has been attempted by unscientific persons. When men like Herschel and Lyell, Darwin, Tyndall, and Huxley, undertake the real popularization of science, we have at once the promise and the sign of progress. "But," Mr. Appleton says, "there is not wanting evidence that the popularization of science, in the best and most necessary meaning of the word, is in this country beginning largely to take the place of original study and investigation of truth." Where, however, is this evidence? Mr. Appleton must have been sorely pressed, when he can only find it in the fact that "in Oxford, where the business of education has been brought to a pitch of perfection almost unequaled elsewhere, the actual additions to knowledge that are made, in the course of a generation, in the old traditional studies of Latin and Greek philosophy, are, as compared with what is done in Germany, almost inappreciable." I am not concerned to deny this, or even to question it. It is the natural result of old traditional arrangements. But it proves nothing concerning the effect of the popularization of science in the best sense of the word—and as distinguished from what is often so called, but might more correctly be termed the vulgarization of science. It seems to me undeniable that the great improvement which has of late taken place in the work of correct scientific exposition has synchronized with a great increase in the amount of fruitful original research. I say simply that the two developments have synchronized; but I am strongly of opinion that they stand to each other in the relation of cause and effect. Not only does it appear to me that our Herschels, Darwins, Huxleys, Tyndalls, and so on, have gained as science workers rather than lost, by their work in popularizing science, but I cannot doubt that the number of science-workers, in the several departments to which their writings relate, has been largely increased by treatises which combine sound science with clear and elegant exposition.

There is another aspect in which the improved scientific literature of our time must be considered. It is unfortunate that modern scientific progress necessarily tends to increase the number of specialists. Not only is it impossible for any man to thoroughly master several departments of scientific research, but no man can be thoroughly master of a single science in all its developments. It is absolutely necessary that there should be specialists—nay, every real worker in science must be a specialist. But while each science-worker has thus, and should have, his special branch of his own science, it is very desirable that he should also have a correct general view of other sciences. If he ought to know every thing about something, there is no reason why he should not know something about every thing.[1] It

[1] "The specialists," says Wendell Holmes, "are the coral insects that build up a reef. By-and-by, it will be an island, and, for aught we know, may grow into a continent. But

is just this something which the student of one science learns from a sound exposition of another science by a proficient therein. Every true popularizer of science knows that among his readers, if not even forming the greater number of his readers, there will be men of science, working in other branches, but still bringing to the study of his treatise their scientific training. Writing for them, he will write in the manner best suited to popularize without vulgarizing science: "the coarser developments of sensationalism" will be avoided, even if the good sense of the scientific worker were not normally opposed to all such faults of style. The literature of science owes much to the recognition of this circumstance.

Some may question, however, whether scientific literature can be sufficiently remunerative to support science-workers, even though they should turn altogether from original research, and devote their whole time to writing about science. I do not think, however, that much anxiety need be felt on this score. Of course, scientific literature is not at present, and perhaps may never be, so remunerative as novel-writing, historical literature, biography, travels, and so on. Very few writers on science, however general the interest attached to their researches, have earned an income of (let us say) five thousand pounds annually for many successive years; and I suppose the successful novelist would regard such an income as contemptible. Probably, in the majority of instances, it would be only by an almost entire withdrawal from original work that the writer on science could earn a steady income of half that amount; while that earnestness in the cause of science which can alone render scientific writings attractive would compel the scientific author to devote a large share of his time to unremunerative work. Yet there can be no doubt that many of our most successful workers in science have been able, without forsaking original research, to gain very sufficient incomes by scientific literature, or by the associated work of popular scientific lecturing. The chief objection, perhaps, to this way of rendering scientific research self-supporting consists in the fact that every hour devoted to

I don't want to be a coral insect myself. I had rather be a voyager that visits all the reefs and islands the creatures build, and sails over the seas where they have as yet built up nothing. I am a little afraid that science is breeding us down too fast into coral insects. A man like Newton, or Leibnitz, or Haller, used to paint a picture of outward or inward Nature with a free hand, and stand back and look at it as a whole, and feel like an archangel; but nowadays you have a society, and they come together and make a great mosaic, each man bringing his little bit and sticking it in its place, but so taken up with his pretty fragment that he never thinks of looking at the picture the little bits make when they are put together." This is true of specialists who are only specialists. But there can be no reason why the student of science should limit his attention to his specialty, though there is abundant reason why he should avoid any attempt to make *researches* over too wide a range of ground. His researches in his own special corner of science will lose nothing in value, but gain greatly, by an occasional survey of the work of others; only let him not pretend to take part in actual work in many parts of the field he thus surveys.

original work involves a pecuniary sacrifice, and the temptation must, in some instances, be strong to withdraw entirely, or for long intervals, from the real work of scientific research—even if this may not become, in many cases, an absolute duty.

Another source of remuneration for scientific workers depends on the value of scientific knowledge in certain departments of commercial enterprise. This means of support, however, though large in individual instances, is so limited in scientific range, that we need not stop to consider it in connection with the general question of support from workers in science. As Mr. Appleton justly remarks, "this source of maintenance is not only the exclusive privilege of physical science, but almost the exclusive privilege of one of the physical sciences. There is no commercial career open for a biologist, for instance; and the existence of a commercial career—and frequently a very lucrative one—for the chemist has the effect of starving all the other sciences for the benefit of one of them. One of our foremost teachers of biology complained to me not long ago that he was compelled to advise his best pupils, who were desirous of devoting themselves to a life of research, to give up their own study, and enter upon that of chemistry, as there was no prospect of a career for them in any thing else."

I have not spoken thus far of salaried offices which are apparently scientific but in reality involve continuous labor not tending greatly to the advancement of pure science. Such, for example, in astronomy, are the various offices, ruling as well as subordinate, in our great government observatories. The details of observatory-work are not, properly speaking, scientific. They involve, no doubt, the continuous application of scientific principles, but no such processes as are likely to lead to discoveries in science. The ordinary notion, for instance, that the large telescopes of our national observatories are employed in advancing our knowledge of astronomy, is altogether erroneous, as any one will perceive who examines the records of the work done in those observatories. All the original researches effected at Greenwich, since Flamsteed's time, would together form little more than a fair life's work for a single zealous student of astronomy, and would be incomparably surpassed in scientific interest by the work of either of the Herschels. The object for which government observatories are erected, in fact, precludes almost entirely the pursuit of original researches. The observations of the moon, for instance, which have formed so important a part of the work accomplished at Greenwich since Flamsteed's time, were not intended to add to our information about the physics of astronomy, though, of course, they have done so in a remarkable degree, studied as they have been by mathematicians (mostly outside Greenwich) from Newton downward. Their ostensible object was the improvement of navigation; and almost every observation made at Greenwich, until quite recently, was directed either to

this end (the improvement of navigation as a science) or to secure continued time-measurements, magnetic data, and other information for the guidance of seamen.—*Contemporary Review.*

## SKETCH OF WILLIAM ROBERT GROVE.

THE subject of this sketch is a typical example of that remarkable class of men who achieve great eminence, both in business and in science; he is a very distinguished scientific investigator, having not only made his name a household word in all chemical laboratories where galvanic batteries are used, but he was one of the early pioneers in establishing the grand doctrine of the correlation of forces, and is known and esteemed throughout the scientific world for his share in this great movement. He has also been a hard-working professional lawyer, forcing his way to legal distinction among his countrymen, becoming queen's counsel, until at length, passing from the bar to the bench, and taking a distinguished rank among the judges of England.

William Robert Grove was born in Swansea, Wales, July 14, 1811, and received his early education at the Swansea Grammar-School. His father, who was a magistrate, intended him for the Church, and he was sent to Oxford in 1830, completing his university term with honor in 1833. He had conscientious scruples that were opposed to his father's desires, and he adopted the profession of the law. He also married about this time, and quitted England for a while to travel on the Continent for his health. In this leisure he took to the reading and study of electricity, soon followed by original experiments and important discoveries in this branch of science. In 1835 he became Professor of Natural Philosophy in the London Institution, a place which he held for five years. His scientific researches have been mostly in the field of electricity, and his contributions on this subject have been numerous in the "Philosophical Transactions," the *Philosophical Magazine*, and other journals of science. In 1839 we find him communicating to the Académie des Sciences de Paris the fact that if a positive electrode be immersed, half in water, and the other half in a tube of hydrogen, and a negative electrode in water and oxygen, the water ascends in the tubes, the galvanometer is deflected, and the water is decomposed and recomposed by voltaic action. This same year he communicated to the French Academy his invention of the galvanic battery, now bearing his name, in which platinum is substituted for copper, and nitric acid for sulphuric. He also published in this connection a paper on the "Inaction of Amalgamated Zinc in Acidulated Water," in which this phenomenon was first satisfactorily explained. About the same time he discovered that if

two pieces of gold are placed one in a cell of nitric and the other in one of hydrochloric acid, separated by an earthen-ware partition, no chemical action takes place; but, if the two pieces be connected by a wire, the acids immediately attack them. In 1840 he was elected a Fellow of the Royal Society, and in 1841 he published a paper "On the Combinations, by the Voltaic Battery, of Azote and Hydrogen with Metals." This same year he excited a great deal of interest by exhibiting, before the Electrical Society, daguerreotype pictures engraved by electricity. The picture was joined with the positive pole of a battery, and placed in hydrochloric acid; the chlorine set free attacked the silver surface unprotected by mercury, and from this etched surface an electrotype was made to be printed from. Though now in active practice at the bar, he continued his electrical investigations. He brought out his voltaic gas-battery, and wrote a paper on its applications to endiometry; published a "Memoir on the Action of Phosphorus, Sulphur, and the Hydrocarbons in the Gas-Pile;" and a communication on the "Electric Action by the Approximation of Dissimilar Metals without Contact," in which he showed that when a disk of zinc and one of copper are approximated without touching, and then separated, the gold leaves of an electroscope diverge, proving the existence of a radiating force capable of exciting electrical disturbance. In January, 1842, Mr. Grove delivered a lecture at the London Institution "On the Progress of Physical Science," in which the doctrine of the correlation of physical forces was briefly but clearly enunciated. He delivered a course of lectures at the same place, in which he explained and illustrated the propositions briefly laid down the year before. The position he sought to establish was that heat, light, electricity, magnetism, chemical affinity, and motion, are all correlatives; that is, that either of them, as a force, may produce the others. As an illustration, in one of these lectures he used a train of revolving wheels; the smallest, or that which revolved most rapidly, was of metal, and contained a piece of phosphorus in it. While this revolved with great rapidity, the phosphorus remained cool, but by a contrivance the wheel was suddenly stopped, and the phosphorus took fire; the object of the experiment being to show that *arrested motion* becomes heat. In 1847 he issued his work "On the Correlation of Physical Forces;" and in 1852 he published a memoir in the "Philosophical Transactions," on the "Electro-Chemical Polarity of the Gases." In 1856 he experimented upon the application of electricity as a mechanical power, and showed that, when by electrical attraction or repulsion, a weight is suspended, it is at the expense of electric tension, and that the spark cannot traverse the same distance that it could traverse, with the same apparatus and charge, without the elevation of the weight. Other researches of his have been on "The Electricity of Flame" and the formation of a flame-pile capable of producing chemical decomposition.

## CORRESPONDENCE.

*To the Editor of the Popular Science Monthly:*

DEAR SIR: Last summer, at the Hartford meeting of the American Association for the Advancement of Science, a new constitution was adopted, and, under its provisions, a permanent subsection of "chemistry, chemical physics, chemical technology, mineralogy, and metallurgy," was organized.

Prof. S. W. Johnson, of Yale College, was elected chairman of the new subsection for the ensuing year, and the undersigned was deputed to make the necessary efforts to insure a full attendance of chemists and others interested in the application of chemistry. The meeting for the summer will be held at Detroit, commencing the 11th of August, and continuing about a week. It is very desirable that there should be a full attendance in the new subsection, in order to make it a success. Will you be so kind as to call the attention of your readers to the subject, either by printing this card, or by an editorial notice?

Any one who is interested in chemistry, mineralogy, or in any application of these sciences, will be welcome. Hitherto, chemistry has been but little represented in the proceedings of the Association, and the time now seems to have arrived in which some good work can be done.

Respectfully,

F. W. CLARKE.

## EDITOR'S TABLE.

### *UNDER FALSE COLORS.*

THE so-called "Association for the Promotion of Social Science" held its last meeting in May, in Detroit. It is reported as a satisfactory session, there having been a good attendance, much interest, and a full invoice of papers upon the varied topics which it is the habit of the body to consider. That the Association performs a useful function in securing the discussion of grave public questions, and in disseminating information, more or less useful, concerning them, we are not at all disposed to question; but we miss (as we did a year ago) any thing in the proceedings answering to the definite object of the organization as put forth in its title. The name of the Association is entirely misleading: it avows one object, and pursues others; it professes to do a certain work of very great public importance, and then, by totally neglecting it and doing something else under its name, it produces a mischievous confusion in the public mind, and becomes detrimental to the very purpose which it distinctly professes to advance.

As judged by its title, the Association was instituted to do an explicit thing, that is, to promote a certain science. Now what does this imply? It implies doing for the particular branch of science chosen, just what other associations do for the promotion of other branches of science. It implies, first, a branch of knowledge capable of assuming a scientific shape, and of definition and limitation in its objects; secondly, it implies efforts and measures for the elucidation of the subject, the extension of observations upon it, the generalization of its facts, by the same patient processes and cautious method that are adopted in other sciences with the single and supreme object of arriving at the truth; and, lastly, it implies men who will devote themselves to the cultivation of the subject in the true scientific spirit, men trained to original

inquiry, widely informed in the subject-matter of investigation, and determined to push it forward in new directions, and arrive at trustworthy and valid results. Social science is to be promoted, if promoted at all, in this manner, and by such men. It implies the systematic treatment of social phenomena, with the view of reaching a definite, coherent, and settled body of social truths, by the collection, analysis, and classification of the proper data of the subject. If the science is in its infancy, and has as yet been only roughly outlined, the work of its cultivators must needs be elementary, and the proceedings of any body of its true promoters will necessarily be characteristic of the stage or state of the subject. In the growth of all the sciences there has been an inevitable order of mental procedure, an advance from simplicity to complexity, from the uniform to the multiform, from the lower to the higher; but though this method has been necessarily followed, mental power has been immensely wasted by ambitious essays to resolve the larger and more difficult aspects of phenomena first. Yet the sciences have been actually and only built up by laying the foundations first and erecting the superstructures afterward.

But all this is of small account to the members of the "Association for the Promotion of Social Science." They do not seem, in fact, to know what the science is that they have assumed the task of promoting. They were in a muddle about it at starting ten years ago, and, if we may judge from the secretary's report, they are much in the same condition still. At any rate, they have little notion of plodding among the rudiments of the subject.

There were able disquisitions at Detroit on Finance, International Law, Life-insurance, Ideal Education, Medical Charities, Immigration, State Churches, Steamship-lines, etc., etc., but they had none of them any more to do with the science of the social relations of mankind than the proceedings of any other convention of thoughtful men called to deliberate upon important public affairs.

We make these remarks in no captious spirit, and we cordially concede the usefulness and importance of much of the work done by this organization: we are only speaking in the interest of that which the Association professes to do, but really does not even recognize; and what it pledges itself to do or to attempt, by the very title it takes, we hold to be far more important than all it accomplishes. The working out of the principles of social science, of the natural laws of the social state, into a clear, comprehensive, and authoritative form, is a matter of great moment, both because the state of knowledge at the present time makes it more possible and practicable than ever before, and because the results of even its partial accomplishment will be of immense value in the management of social affairs. And because of its grave importance, we strenuously object to any perversion or misappropriation of the term to illegitimate uses. We object to its employment as merely a dignified title for miscellaneous speculations on human affairs. Social science is a something yet to be achieved—a well-defined branch of inquiry yet to be elaborated by the prolonged efforts of painstaking thinkers; and we protest against its use as a kind of imposing category for the schemes of philanthropists and the projects of reformers. It may seem a matter of small importance what name an association chooses to adopt, but it is not so in the present case. The misuse of terms leads to false views that are liable to produce the most injurious consequences. No one can be better aware of the potent misleading influence of words upon the public mind than the distinguished president of the Detroit meeting, Hon. D. A. Wells. He perfectly understands that only a few people go beyond the word to the qual-

ity of the thing indicated. He knows that the policy of restriction imposed by the State upon the freedom of commercial interchange, by which monopolists are enriched, the people plundered, the Government corrupted, and the country disgraced, is intrenched in popular misconception, because it has got itself labeled "protection." The case before us is equally in point. So long as the term "social science" is employed to characterize the heterogeneous and discordant opinions of unscientific men upon the most intricate and refractory problems of civilized life, it will be discredited in its true application.

The American Social Science Association has been running for ten years, and its British prototype has had a conspicuous career for twice that time, but so little have they done toward the real promotion of the subject, so little to prepare the public for it, and so much to disseminate erroneous views respecting it, that the most comprehensive and solid contribution yet made to sociological science—a work entirely free from speculation, and which aims to lay the foundation of the science by collating and arranging the elemental facts descriptive of all types of social structure—cannot get patronage enough even to pay for carrying on the publication; and the real difficulty is the false impressions of the subject that have been fostered and disseminated by those who have acquired weight with the public as its promoters.

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### *CORRECTED AGAIN.*

THE ex-President of Harvard College, writing in the *Unitarian Review*, revives the perversion of Prof. Tyndall's views on the prayer question in the following pointed words: "Let the President of the British Association refrain from insulting Protestant Christians by proposing an arithmetical test of the reality of the communion of the soul with God." We are curious to know where Dr. Hill got his evidence for the charge that Prof. Tyndall has ever proposed "an arithmetical test of the reality of the communion of the soul with God," or any evidence that he has ever questioned that reality. To the conception of prayer as inspiration, communion with the Divine Spirit, or the expression of devotional feeling, we are not aware that Prof. Tyndall has ever made the slightest objection. On the contrary, we know, by his own repeated avowals, that he recognizes the religious efficacy of prayer as a "strengthener of the heart," which "in its purer forms hints at disciplines which few of us can neglect without moral loss." Again, he observes: "It is not my habit to think otherwise than solemnly of the feeling that prompts prayer." This, surely, is very far from being the language either of denial or of insult.

As to the so-called prayer-test, it was not to try "the reality of the communion of the soul with God" that Sir Henry Thompson proposed it, and Prof. Tyndall indorsed it by sending the anonymous article to the *Contemporary Review*. The object was, indeed, very different from this. It was to determine the validity of what may be called the physical theory of prayer; to ascertain the value of petitions to God for intervention in producing designated physical effects, such as changing the weather, augmenting the crops, or staying disease in special answer to such petitions. It was to the conception of prayer as critical and advisory, as objecting to this and calling for that, as invoking a potency that is available to man for the attainment of specific ends in the natural world, such as can be only in this way secured, that it was proposed to apply some rational method of verification.

The effects claimed being physical, it is the legitimate work of science to search out and measure every agency by which they are influenced. Nor

is even this the sinful occupation that religious people often assume, for the laws of Nature are the laws of God, and no man can be more reverently occupied than in investigating their operations. The laws of God, we venture to think, do not shrink from any thoroughness of verification, and those who conceive themselves insulted by the application of the balance or the spectroscope, geometry or arithmetic, to any of the physical operations of the world, must entertain a very narrow and morbid view of the divine government. It would seem that the old religious prejudice against the study of Nature, as a profane occupation of the human mind, in contrast with the sacredness of theological studies, still survives, and that the old conflict is yet very far from having died out. If it be said that the doctrine of answer to prayer, by immediate and miraculous suspension of the course of natural changes, has passed away, and has been replaced by the doctrine that the answer comes through the operation of natural laws, we reply, that the proof of this position is wanting. We hazard little in the assertion that, if the question were submitted to the suffrage of Christendom, those who hold to this interpretation of prayer would not only be in a paltry minority, but would be voted as infidels and apostates from the faith. The fact cannot be escaped that multitudes of devout people still strenuously hold to immediate divine intervention in the course of natural things, in response to human supplication. A periodical before us, representing the faith of half the Christian world, says: "Suppose, then, that a whole city full of people should testify to the resurrection of a dead man from the grave; would we be justified in rejecting the testimony on the sole ground of the physical impossibility of the occurrence? . . . History abounds in instances of the sort, in recitals of sudden cures witnessed by thousands, of conflagrations suddenly checked, of plagues disappearing in a moment." That such beliefs were universal in past times is notorious; that they have been dissipated from many minds is purely owing to what is called the encroachment of science. But the mass of people are still very far from having so clear, and settled, and strong a conviction of the physical order of Nature, that they will not lend a willing ear to the most preposterous stories of its violation. What is the lesson of the gross ghostology of modern spiritualism, before which even educated people will throw up gravity, and all the laws of physics, at the first puzzle of a juggling exhibitor, unless it be that the scientific doctrine of the government of the world by inviolable law is yet far from being firmly rooted in the general mind. Those who entertain such loose views of the constitution of Nature will almost necessarily take to the superstitious side of religion, and resent all attempts to submit their beliefs, even where they involve physical effects, to the test of science.

## LITERARY NOTICES.

The Life and Growth of Language: An Outline of Linguistic Science. By William Dwight Whitney. Pp. 326. New York: Appletons (International Scientific Series, Volume XVI.). Price, $1.50.

Ever since the fifteenth century the study of languages, particularly of Latin, Greek, and Hebrew, has formed the basis of a "liberal education;" and yet it was not till our own day that such a thing as a science of language was thought possible. Generation after generation trod the beaten path of grammar, loading the memory with formulas of accidence and syntax, learning by heart whole books of the "Iliad" and the "Æneid;" a few, and only a few, getting an insight into the habits of thought of the great poets, philosophers, orators, and historians of antiquity. For the few the study of the classics was an inestimable benefit. it undoubtedly did serve to broaden and lib-

eralize their minds; but the many derived from their toilsome labors absolutely no fruit. On the contrary, this mill-horse toiling up and down, and round and round, ever treading the same old tracks of declension and conjugation, ever "parsing" and translating without being able to see whither it all tended, could serve only to dull and deaden all the faculties of the mind, and to stamp out all originality.

The old school in language had a theory of the origin of the various tongues of mankind: they all sprang from one—the Hebrew. Whether true or false, this theory was unproductive of results which could, by any possibility, inform or instruct the mind, for it was at the same time affirmed that the descendants of the Hebrew language were purposely so distorted that human ingenuity would ever fail to show a connection between the children and the parent, or between the children themselves. But, by the researches of modern scholars, even the arbitrary (for so they, till recently, seemed to be) modifications of words, as found in declension, conjugation, and the like, have been traced to their sources, and good reasons ascertained why they are thus and not otherwise. In this way caprice is eliminated from language, and law set up in its place; language is made amenable to scientific treatment.

Prof. Whitney's book outlines with wonderful clearness the science of language; and in the deservedly popular series to which it belongs there is not one volume which surpasses this as a simple and lucid exposition of a scientific theme. His method is to start from obvious, familiar truths, to exemplify by facts that are well known, and hence he is always, in his speculations, within easy reach of the reader. This common-sense mode of treating his subject is seen in Prof. Whitney's discussion of the question, How is language obtained by us? "There are few," he says, "who would not at once reply that *we learn* our language; it is taught us by those among whom our lot is cast in childhood." And this reply the author accepts as the true one, rejecting two other answers: that language is a race-characteristic, and as such inherited from one's parents, like the physical constitution; and that it is independently produced by each individual, in the natural course of his bodily and mental growth. The author then proceeds to show that language is *not* inherited, and that it is *not* evolved by the mind of the individual, but simply learned, acquired by hearing and practice.

As an illustration of the influence upon language of conservative and alterative forces, Prof. Whitney very happily selects a verse (Matthew xii. 1) from the Anglo-Saxon Gospels and compares it with the same verse in our modern English: "Se Hælend fôr on reste-dæg ofer æceras; sôthlice his leorning-cnihtas hyngrede, and hî ongunnon pluccian thâ ear and etan." Modern version: "Jesus went on the Sabbath-day through the corn; and his disciples were an hungred and began to pluck the ears of corn and to eat." In the Anglo-Saxon version it is not easy for the ordinary English reader to recognize the words as familiar, and yet, by translating it as literally as we can, we find that almost every element in it is still good English. Thus: The Healing (one) fared on rest-day over (the) acres; soothly, his learning-knights (it) hungered, and they began (to) pluck the ears and eat. By means of this one passage Prof. Whitney indicates all the change-influences to which language is subject. These are: "I. Alterations of the old material of language; change in the words which are still retained as the substance of expression; and this of two kinds or sub-classes: 1. Change in altered form; 2. Change in content or signification. II. Losses of the old material of language, disappearance of what has been in use; and this also of two kinds: 1. Loss of complete words; 2. Loss of grammatical forms and distinctions. III. Production of new material; additions to the old stock of a language, in the way of new words or new forms; external expansion of the resources of expression." Five chapters of the work are devoted to an exposition of the influence of these various causes upon language.

We have not space for more than mere mention of the titles of the remaining chapters of the work, viz., Dialects; Indo-European Language; Linguistic Structure; Material and Form in Language; Other Families of Language: their Locality, Age, and Structure; Language and Ethnology; Nature and Origin of Language.

The Sexes throughout Nature. By Antoinette Brown Blackwell, Author of "Studies in General Science." Pp. 240. G. P. Putnam's Sons. Price $1.25.

The line of argument upon the woman-question which was opened by Mrs. Blackwell in an article in The Popular Science Monthly on the alleged antagonism between growth and reproduction, and which was subsequently still further pursued in these pages by Dr. Frances Emily White in papers on "Woman's Place in Nature," is carried out in the present volume with considerable elaboration. It is a monograph, written to establish, on scientific grounds, the equality of the sexes throughout Nature. Both Mrs. Blackwell and Miss White are students of science, and recognize that in its later progress, especially in biology and psychology, it has direct and important bearings upon the issues raised in the women's movement. They recognize Darwin and Spencer as representing the most advanced scientific results, but object to the conclusions at which these gentlemen have arrived, on the subject of the relations of the sexes. Mrs. Blackwell's work is therefore not an attempt merely to expound the present state of science, but it aims to controvert conclusions deemed erroneous, and which have weight because emanating from high authorities. Of her book we may say that it is written in a clear and excellent style, contains much interesting information which will be fresh to many readers, and abounds in acute suggestions and ingenious views, while the publishers have got it up in an attractive form.

But, considered as an original scientific argument, we fail to see that Mrs. Blackwell has advanced or altered the position of the question she has taken up. She undertakes to prove that throughout all Nature the sexes are equal. We will not say that this is an impossible task; but if it be attempted in a truly scientific spirit we have no hesitation in saying that even the proximate solution of her problem belongs to the very distant future. For what she proposes to do is nothing less than to reduce the whole organic world, with all its vital and psychical characters, into exact and demonstrable quantitative expression. She puts the problem sharply, saying: "This is a subject for direct scientific investigation. It is a question of pure quantity; of comparing unlike but strictly measurable terms. In time it can be experimentally decided and settled by rigid mathematical tests." Accordingly, she reduces the elements of her subject to the form of equations, and, making an analysis of the characters and functions of the sexes in insects, fishes, cetacea, birds, herbivora, carnivora, and man, she aims to establish the equivalence of their relations. Special attributes she admits to be variable, but, taking the totality of attributes and bringing them together as balancing quantities, she maintains that throughout Nature the sexes are strict mathematical equivalents of each other.

Mrs. Blackwell seems to us to be quite oblivious of the difficulties of the task here undertaken. We know how long and painfully even the lower and simpler sciences toiled through their qualitative stages, before they reached the possibility of entering upon their quantitative relations. And we know, too, how the difficulties have thickened in prosecuting these sciences to their higher stages, even where all the effects are capable of being dealt with by direct experiment. But when we pass to the organic sciences these difficulties are immensely heightened. That organic phenomena are governed by quantitative laws is no doubt true, and it is the duty of science to work them out as fast and as far as it can; but, considering the vastness of the work, we can hardly regard it as yet fairly begun. Certain important physiological constants have been determined with some accuracy of general expression. The weight of the parts—skeleton, muscles, and brain—the proportions of chemical constituents, the rates of respiratory change, the statistics of circulation, the balance of assimilation and waste, and the relation of the expenditure of mechanical force to the food consumed, have been arrived at in a general and proximate way, after centuries of labor by the physiologists of all nations. Even to these results it would be wholly inadmissible to apply the term exact. But, when we rise to more complex organic manifestations, to the functions of the nervous system, to feeling and thought, and those pro-

portions and combinations of characters which distinguish classes and individuals, nothing whatever has been done toward their quantitative elucidation, and we can only say that the phenomena are vaguely comparable as more or less.

To illustrate the difficulties of attaining exact ideas in relation to quantity, we may refer to the history of chemistry, a science in which all the phenomena are at absolute experimental command. A century ago the law of exact proportions in chemical combination was arrived at, and, from the equality of affinity and neutralization among different bodies, they were held to be equivalents of each other, and the term "equivalence" came to be settled and fundamental in expressing chemical relations. But, after a hundred years of the closest thinking and the most exact experiment, we now find that the "old chemistry" is swept away, and the idea of "equivalence," which was its corner-stone, has gone with it. With the new facts, and finer discriminations, and broader views that have arisen, a whole crop of new terms has sprung up, and, instead of the equivalence of combining bodies, we now speak of their "univalence" and "multivalence," their "bivalence," "trivalence," "pentivalence," etc.; and, finally, the whole set of relations has to be expressed by the general term "quantivalence." But if the conception of equivalence is thus discredited in one of its oldest and simplest scientific applications, what meaning can it have when applied to phenomena that have not yet even taken on the quantitative form? We can write down the contrasted characters of the sexes, as Mrs. Blackwell has done, and carry them out to no end of detail, and prefix the terms *plus* and *minus* to the elements that are brought into comparison, and thus give a general idea of Nature's compensations; but to undertake to add up or to reduce to any strict equational form these most indefinite things seems like trifling. With man the scheme of comparison is carried out to nineteen particulars, of which the following five are examples:

| MALES. | FEMALES. |
|---|---|
| — Structure. | + Structure. |
| + Size. | — Size. |
| + Strength. | — Strength. |
| — Endurance. | + Endurance. |
| — Products. | + Products. |

We looked over this enumeration with special interest, to see what value would be assigned to maternity, the grand function of the female sex, to which every thing else is subordinated. But it is either left out of the estimate, or must be included under products. Maternity is thus so generalized as to be described in terms applicable to both sexes. Now, we do not like this depreciation of the feminine side. Denying, as we do, the equality of the sexes, and holding to the superiority of the female sex, we protest against the degradation of woman implied in losing the supreme and distinctive purpose of her nature among the *plus* and *minus* products common to the sexes.

THE TEXT-BOOK OF BOTANY, MORPHOLOGICAL AND PHYSIOLOGICAL. By JULIUS SACHS, Professor of Botany in the University of Würzburg. Translated and annotated by ALFRED W. BENNETT, F. L. S., assisted by W. T. THISELTON DYER, F. L. S. Macmillan & Co. Pp. 848. 461 Illustrations. Price $12.50.

THIS admirable translation of the work of Prof. Sachs supplies a want long felt in our literature. Students who have been cut off from the German work, by their inability to read that language, may congratulate themselves that, for once at least, the translation offers advantages not found in the original. The Germans, it is well known, are doing a very large proportion of the world's thinking, and it has been hinted that the German consciousness of this fact is perhaps somewhat exaggerated, and may sometimes betray its men of learning into an unprofitable ignoring of the labors of other nations. But no criticism of this kind will hold against the present volume. Its translators, being themselves eminent botanists, have enriched the work with comments and contributions embodying English thought and discovery in this important division of science. We may also add that the German work reached its fourth edition while the translation was passing through the press, so that the new views adopted by the author, and the new matter added, are indicated in the English volume.

This text-book of Prof. Sachs is at once comprehensive in scope, and minute and accurate in detail. It is the aim of the author

to introduce the student to the present state of knowledge in botanical science. He not only explains the phenomena of plant-life already accurately known, but also indicates those theories and problems in which botanical research is at present engaged. References are given throughout the volume, which direct the student to those writings that contain fuller discussions of the points in question, that he may be enabled to form for himself an enlightened judgment. The illustrations are mostly original, and many of them the result of laborious investigation.

The work consists of three divisions: General Morphology, Special Morphology, and Physiology. Under General Morphology, there are three chapters treating: 1. Of the morphology of the cell; 2. Morphology of the tissues; and 3. Morphology of the external conformation of plants. Special morphology deals with the groups of plants as at present arranged in classes. Physiology is treated in seven chapters: 1. On the molecular forces in the plant; 2. Chemical processes in the plant; 3. General conditions of plant-life; 4. Mechanical laws of growth; 5. Periodic movements of the mature parts of plants, and movements dependent on irritation; 6. The phenomenon of sexual reproduction; 7. The origin of species.

The general reader, who is interested in modern scientific discussion, will find this an entertaining volume, because of its vital relation to questions uppermost in modern thought. For instance, the world-wide interest in "protoplasm" aroused by Prof. Huxley's address at Edinburgh, finds ample satisfaction in the explanations of cell-structure and cell-function. As bearing upon this subject we quote the following, which will be new to many readers:

"Under this head" (*Myxomycetes*) "is included a numerous group of organisms which, in many respects, differ widely from all other vegetable structures, but, in the mode of formation of their spores, stand nearest to fungi, on which account we may treat them as a supplement to that class. The *Myxomycetes* are remarkable in no ordinary degree from the fact that, during the period of their vegetation and assimilation of food, they do not form cells or tissues. The protoplasm, which in all other plants is also the general motive power of the phenomena of life, remains in them during the whole of this period perfectly free, collects into considerable masses, and assumes various shapes from the internal force residing in it without becoming divided into small portions, which surround themselves with cell-walls (or become cells). It is only when the protoplasm passes into a state of rest in consequence of being surrounded by unfavorable conditions, or when it concludes its period of vegetation by the formation of the reproductive organs—its internal and external movements ceasing at the same time—that it breaks up into small portions which surround themselves with cell-walls, and which even then never form a tissue in the proper sense of the term."

The book is penetrated throughout with modern views in biology, and also illustrates the truth of the remark that, while other nations are disputing about the doctrines of Darwin, the Germans accept them, and are working on the new basis afforded by them. In the chapter on the "Origin of Species," full of the fruitage of this new line of study, we find the following:

"The scientific basis for the theory of descent rests in the fact that it alone is able to explain in a simple manner all the mutual relationships of plants to one another, to the animal kingdom, and to the facts of geology and paleontology, their distribution at different times over the surface of the earth, etc.; since it requires no other hypothesis than descent with variation, and the continued struggle for existence which permits those forms only to persist that are endowed with sufficiently useful properties, the others perishing sooner or later. But both these hypotheses are supported by an infinite number of facts. The theory of descent involves only one hypothesis that is not directly demonstrated by facts, namely, that the amount of variation may increase to any given extent in a sufficiently long time. But, since the theory which involves this hypothesis is sufficient to explain the facts of morphology and adaptation, and since these are explained by no other scientific theory, we are justified in making this assumption."

Sixth Annual Report of the State Board of Health of Massachusetts. 379 pages. January, 1875.

This report opens with a feeling tribute of respect, from the pen of Dr. Henry I. Bowditch, Chairman of the Massachusetts State Board of Health, to the memory of

Dr. George Derby, its former able Secretary, who died June 20, 1874; and to whose excellent judgment and untiring exertions the usefulness of the Board in past years, and its present high position as an authority in sanitary matters, are largely due.

The subjects of the papers contained in this report are the following:

"Inebriate Asylums or Hospitals," by Henry I. Bowditch, M. D. In this paper the line has been drawn between vicious and morbid drunkenness: yet the former may finally become the latter. The writer suggests a means of dealing, through inebriate asylums, with one of the most troublesome questions of the day. The Board, feeling the importance of the subject, has passed a resolution recommending to the Legislature, as a sanitary measure of the highest importance, the establishment or endowment of one or more inebriate asylums or hospitals.

"The Value of Health to the State," by W. E. Boardman, M. D., of Boston. Whether all disease, or any class of diseases, can be prevented or "stamped out" or not, the experience of all countries has shown that the death-rate may be very sensibly diminished by attention to sanitary laws; and the writer has shown in this article that the State can afford to spend some millions of dollars in saving to itself the immense losses now occasioned by disease and consequent poverty in its citizens.

"On the Transportation of Live-Stock," by J. C. Hoadly, Esq., of Lawrence, member of the Board. This essay will commend itself to all persons interested in cattle-transportation, whether financially or from a desire that the transportation and slaughtering of animals may be attended with the least amount of suffering possible, and be conducted in a way to secure to the community the best meat.

"Our Meat Supply and Public Health," by C. F. Folsom, M. D., Secretary of the Board. In this paper are considered the various diseases, parasitic and others, which affect the quality of butcher's meat considered as an article of food for man. The opinions of experts in reference to other conditions in which animal food is sometimes found, and some facts bearing upon the question of its suitableness for our markets, are also shown. The writer divides meat into three classes: 1. That which is unquestionably of first-rate quality, and from animals perfectly sound and healthy; 2. That which is innutritive or lacking in the qualities which the best meat should possess, and inspection is urged for this on economic grounds; 3. That which is positively harmful or dangerous, and in this case inspection is recommended as being necessary on sanitary grounds; finally, the only safe way with regard to pork is shown to consist in never eating it unless thoroughly cooked.

"Cremation and Burial, an Examination of their Relative Advantages," by J. F. Adams, M. D., of Pittsfield. The writer concludes that there exists no necessity, on sanitary or economic grounds, for any change at present, in our manner of disposing of the dead. He shows that cemeteries, if managed with proper care, may be made to conduce to the welfare of the public by affording parks abounding in luxuriant vegetation. At the same time, there is no real objection to cremation, excepting that which arises from religious feeling or association, and which should be respected, so that individuals should be allowed to choose in what way their own remains are to be disposed of.

Other papers are: "The Brighton Abattoir," in which the daily average amount of meat used by each individual of the six hundred thousand supplied by Boston markets is estimated to be about eleven ounces. The paper gives the regulations of the Butchers' Slaughtering and Melting Association, the Revised Sanitary Regulations of the State Board of Health, an Analysis of Butter made from Suet, and the Acts in regard to establishing Abattoirs; "On the Composition of the Air of the Ground Atmosphere," by Prof. Wm. Ripley Nichols, of Boston; "The Ventilation of Railroad-Cars," by T. W. Fisher, M. D., of Boston, with "Chemical Analyses of the Air in Cars," by Prof. Nichols; "Health of Towns;" and a "Report on the Sanitary Condition of the State Prison at Charlestown," close the volume.

The Law of Inheritance, or the Philosophy of Breeding. By E. Lewis Sturtevant, M. D.

The two great efforts of the agriculturist should be how to raise the best crops, and

how to beget and perpetuate the best stock. Any thing that incites thought and action in this direction must advance agriculture and lay more deeply and broadly some of the foundations of national wealth. As Dr. Sturtevant's treatise is of this nature, and is eminently philosophical and scientific, it deserves well of all interested in this class of subjects. Its teachings, if generally understood, will lead to intelligent action in a line in which at present too much is left to lucky accidents.

Memoirs of the Royal Astronomical Society. Vol. xl. A Catalogue of 10,300 Multiple and Double Stars, arranged in the Order of Right Ascension by the late Sir J. F. W. Herschel, Bart., and edited by the Rev. R. Main, M. A., F. R. S., Radcliffe Observer, and the Rev. C. Pritchard, M. A., F. R. S., Savilian Professor of Astronomy in the University of Oxford. London, 1874.

In 1863 Sir John Herschel completed a descriptive catalogue of all the nebulæ and clusters known up to that time, the greater portion of which had been discovered by his illustrious father, Sir William Herschel, and by himself. This was a most valuable and complete compilation, and, although containing a list of no less than 5,079 nebulæ and clusters, it is singularly free from errors. This, no doubt, was in great part due to the careful and repeated revisions of the work by Sir John himself, and also to the fact that many lists of nebulæ existed with which Sir John's catalogue was constantly compared. No adequate idea of the amount of labor expended upon the preparation of this list can be given here, but a reference to the Introduction of that Catalogue must be made, where a concise account of the various revisions, collations, and comparisons, with the reductions executed (always in duplicate), extends over five quarto pages.

As the complete results of the observations of nebulæ were now accessible to astronomers in a convenient form, Sir John Herschel turned his attention to the formation of an equally complete catalogue of double stars. He proceeded assiduously with this work, and at the time of his death he had gathered data relating to over 10,000 stars, and had arranged these stars in order of right ascension, and had formed a synoptical history of all the known observations of about 4,000 of these.

This "Catalogue," in its imperfect state, was bequeathed to the Royal Astronomical Society, and volume xl. of their "Memoirs" contains the work completed in the form they have decided to give it, and for which the Society, jointly with the editors (who were but their agents), is responsible. So far we have given a sketch of the history of these two "Catalogues," gathered mainly from the respective Introductions. We propose briefly to indicate the shortcomings of the double-star catalogue, and we can do this best by comparing it with its predecessor in which Sir John Herschel's own plans were fully carried out by himself, and which naturally should have served as a model for the execution of the later catalogue. We will extract an entry from each of the two catalogues, and will explain these, so that an idea may be formed of the amount of information which can be had about any object contained in the two lists. The following extracts are made quite at random; the first from the "Catalogue of Nebulæ," the second from the "Catalogue of Double Stars:"

No. 2052; 688; I, 168; . . . .; $10^h\,9^m\,49^s.9$; $+3^s.623$; 1; $47°\,53'\,1''.9$; $+17''.83$; 1; p B; v L; R; v g b M; 4.

No. 2052; h 698; . . . .; $5^h\,13^m\,48^s$; $89°\,6'$; $+3^s.09$; $-4''.02$.

The first entry relates to No. 2052 of the catalogued nebulæ, and we learn from it (taking the numbers in their order from left to right) that this nebula is No. 688 of Sir John Herschel's previous catalogue; is No. 168 of Sir William Herschel's Class I.; that no other persons have published any observations of this up to 1863; that its Right Ascension for 1860.0 is $10^h\,9^m\,49^s.9$; that the annual precession in Right Ascension for 1880 is $+\,3^s.623$; that the number of observations upon which this place depends is 1; that its North Polar Distance for 1860.0 is $47°\,53'\,1''.9$; that the precession in North Polar Distance for 1880 is $+17''.83$; that 1 observation was used to determine its position in North Polar Distance; and that this Nebula is "*p*retty *B*right; *v*ery *L*arge; *R*ound; *v*ery *g*radually *b*righter in the *M*iddle; and finally, that it has been

observed 4 times by the Herschels." In short, we know something about this Nebula. Interpreting the entry from the "Double Star Catalogue," we find about No. 2052 that it is No. 698 of Sir John's previously published list; that it has been observed by no one else; that its Right Ascension for 1830 is $5^h\ 13^m\ 48^s$; its North Polar Distance is for the same epoch 89° 6′; and that the precessions in Right Ascension and North Polar Distance are for the same epoch $+3^s.09$ and $-4''.02$ respectively.

There is not a word about the relative magnitudes of the component stars of the double star referred to, not a word to show whether it is double, triple, quadruple, or multiple, not a word about the *position*, *angle*, and *distance* of the component stars of the double (if it is a double), and finally, not a word about the *colors* of the components. In short, we know next to nothing about this star. The little we do know is this: 1. Its position in 1830, and we have the means of determining the position with tolerable accuracy at present; and, 2. We know where to look in Sir John's partial "Catalogues," which are scattered through many volumes of the Royal Astronomical Society's "Memoirs," the observations at the Cape of Good Hope, etc., for the information regarding *position*, *distance*, *color*, and *magnitude*, which is precisely what we require, and which is precisely what is omitted from this new "Catalogue." Thus we may estimate its value to be that of an extended index to various double-star observations, with the approximate positions of these stars. After what we have said, it is unnecessary to go further. Any one can see that to the astronomer this "Catalogue" is of but slight value, while to the average double-star observer (who often has not the means of determining accurately star-positions) it is tantalizing and almost useless. When he finds a double star, how is he to know whether it is new or not, except by going over much of the same work that has been done once by the computer of this "Catalogue?" In fine, this book can only be considered to be truly useful when it is accompanied by the "Memoirs" from which the materials were originally drawn. The publication is not creditable to the Royal Astronomical Society, to the memory of its distinguished projector, nor to its able editors. These gentlemen might well have consulted the work of Dr. Auwers on a similar subject, "*William Herschel's Verzeichnissen von Nebelflecken und Sternhaufen, bearbeitet von* Arthur Auwers, 1862," for a model as to the way in which the memory of a great astronomer should be honored, and as to the manner in which alone it is worth while to do astronomical work.

Seventh Annual Report on the Noxious, Beneficial, and other Insects of Missouri. By C. V. Riley, State Entomologist.

In this volume (published April 1st) Prof. Riley specially considers six insect-pests, viz., the Colorado potato-beetle, chinch-bug, apple-tree borer, canker-worm, *Phylloxera*, and the Rocky Mountain locust, improperly called grasshopper. Mr. Riley gives the results of his observations and inquiries during the past year on each of these different insects, and, as in all his previous reports, keeps steadily in view the great practical object of his research, namely, the discovery of the best and most effectual means of annihilating these enemies of agriculture. In Missouri the farmers now accept the presence of the Colorado beetle as the necessary concomitant of the culture of the potato; but they do not fear it as once they did, being provided with the means of keeping the pest in check. Prof. Riley has, for years, recommended the use of Paris green in the war of extermination against this beetle, and the farmers of Missouri now very generally employ this substance, and with the best results: in short, it is by far the cheapest and most effectual means of destroying the beetle. "But, then, Paris green is a deadly poison, and therefore its use causes more mischief by far than could ever be done by the Colorado potato-bug." Prof. Riley, however, speaks from experience, and he asserts that there is no danger to be apprehended from the use of Paris green, "except through carelessness and exposure to its direct influence." Millions of bushels of potatoes were last year grown in Missouri, and great quantities of Paris green used in sprinkling the leaves of the growing plants, and yet the author has not heard of a single case of poisoning, save where people had

been careless. After discussing the subject very fully, the author concludes with these words: "I would say to those agriculturists of the East who are in any way alarmed by what has been written on this subject, and who hesitate to use the Paris-green mixture—profit by the experience of your more Western brethren, and do not allow the voracious *Doryphora* to destroy your potatoes, when so simple and cheap a remedy is at hand."

The aggregate loss to Missouri farmers, in 1874, from the chinch-bug, is estimated at $19,000,000. The only measure at present known to be effectual against this pest, when it has spread, is irrigation. On the subject of the grape *Phylloxera*, Prof. Riley is an authority both at home and in Europe. A few facts, of interest to entomologists, in the life-history of this insect, are noted in the present volume. Mr. Riley gives a brief narrative of the researches made in France during the year, with a view to discovering a means of destroying this pest. Dumas's method is as follows: A hole is bored with an auger in the earth, near the foot of the vine, and in it are placed about four ounces of alkaline sulpho-carbonate. By decomposition the sulphuret of carbon is formed, which kills the *Phylloxera*, without injuring the vine. We see, from the report of a recent meeting of the French Academy of Sciences, that this method "has been tried with great success in several of the more important vine-growing districts."

The territory in Missouri ravaged by the Rocky Mountain locust in 1866, and again in 1874, is represented in a map, in which is also indicated the direction in which the insects came during the latter year. Last May the Governor of Missouri proclaimed a day of fasting and humiliation as a stratagem in the anti-locust war. Prof. Riley, last year, "prophesied" that the locusts of 1874 would come too late to do much damage. He then asserted, and now asserts, that beyond the extreme western tier of counties Missouri need not dread these invaders. The event has confirmed the accuracy of Prof. Riley's conclusions. The Governor would have done well had he given ear to this truthful prophet, before he uttered his cry of distress.

Determination and Classification of Minerals. By James C. Foye, A. M., Professor of Chemistry and Physics, Lawrence University, Wisconsin. Pp. 38. Price 75 cents. Chicago: Jansen, McClurg & Co., 1875.

The object of this little work, as the author says, is to furnish tables by which the student may, with as few easy tests as possible, determine with precision, and classify, minerals found in the United States, and become familiar with their principal characteristics.

Annual Report of the Board of School Commissioners of the City of Milwaukee, for the Year ending August 31, 1874.

Nothing neater, as respects typography and book-making, can be found in any educational document East. The table of examinations of teachers shows, in the large number of rejections, that honest work is attempted. Superintendent McAllister's scheme for uniform examination of the schools seems to us philosophical.

Systematic Catalogue of Vertebrata of the Eocene of New Mexico; collected in 1874. E. D. Cope, A. M.

This is a *morceau* of Lieutenant Wheeler's Reports. Of this essay the writer says it completes the determination of the fossil vertebrate species obtained in the Eocene of New Mexico during the field-work of 1874. The total species of mammalia is forty-seven, of which this essay "introduces twenty-four for the first time," besides some reptilia and fishes.

## PUBLICATIONS RECEIVED.

The Keys of the Creeds. Pp. 200. New York: Putnams. Price, $1.25.

The Miracle of To-Day. By Charles B. Warring. Pp. 292. New York: Schermerhorn & Co. Price, $2.00.

Heat, Light, Electricity, and Magnetism. By Charles Skelton, M. D. Pp. 75. Trenton, N. J.: Naar, Day & Naar.

Curious Anomaly in the History of Larvæ of Acronycta Oblinita. By Thomas G. Gentry. Pp. 30.

Mysteries of Hierarchy. Pp. 14.

Climatology of Florida. By A. S. Baldwin, M. D. Pp. 39. Charleston, S. C.: Walker, Evans & Cogswell.

Secular Sermons, No. 1. By John McIntosh. Pp. 20. Rochester: C. H. Stump.

Language, its Nature and Functions. By Rev. J. H. Pettingell, M. A. Pp. 26. Washington: Gibson Bros.

Report of the Managers of the State Lunatic Asylum, Utica, for the Year 1874. Albany: Weed, Parsons & Co.

Management of the Insane. By Henry Howard, M. D. Pp. 14. St. Johns, N. B.: *News* Print.

A Protest against the High-Pressure System of Education. Same Author. Pp. 24.

Philosophy of Dairy Manufactures. By F. X. Willard, M. A., of Herkimer Co., N. Y. Pp. 29.

The Aërial World (Hartwig). Appletons.

Problems of Life and Mind (Lewes). Osgood.

What Young People should know (Wilder). Estes & Lauriat.

Storms: their Nature, Classification, and Laws (Blasius). Philadelphia: Porter & Coates.

Certain Harmonies of the Solar System (Alexander).

Lists of Elevations (Gannett).

Fishes of the East Coast of North America (Gill).

Eighth Annual Report of the Trustees of the Peabody Museum.

Meteorological Observations (Chittenden).

## MISCELLANY.

**Notices of Recent Earthquakes.**—The *American Journal of Science* for May gives a summary of earthquakes for the year 1874, prepared by Prof. C. G. Rockwood, Jr., of Rutgers College, New Jersey. They are reported from nearly all quarters of the globe, forty-three in number. Two of these were disastrous, but in most cases the shocks appear to have been light.

Fourteen shocks are reported as having occurred in the United States. The most important of these took place in North Carolina, in Bald and Stone Mountains. The shocks continued at intervals from February 10th to April 17th, with explosive and rumbling noises. The most severe shock was felt February 22d. On one occasion the sound of the shock resembled that made by blasting in a deep quarry, first explosive, then reverberating.

The shock which occurred in the vicinity of New York City, December 10, 1874, is noticed. It extended as far as Peekskill on the north, and Norwalk, Connecticut, on the east. The shock was most severe in the neighborhood of Tarrytown and Nyack, but did no damage anywhere.

The most disastrous earthquakes occurred at and near Harpoot Mission, Eastern Turkey, destroying the houses of Haloosi, a considerable town near that place, and at Volcan del Fuego in Guatemala. This earthquake destroyed the town of Duenos. From a small mountain near the base of the Volcan del Fuego there issued an eruption of cold compact mud.

**Testing Iron and Steel.**—We have received the programme of organization of a Board appointed by the President, in accordance with the provisions of an act of Congress, making "appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1876, and for other purposes."

The instructions of the Board are, to determine by actual tests the strength and value of all kinds of iron, steel, and other metals, which may be submitted to it, or by it procured, and to prepare tables which will exhibit the strength and value of said materials for constructive purposes. The members of this Board are Lieutenant-Colonel T. T. S. Laidley, U. S. A., President, Commander L. A. Beardslee, U. S. N., Lieutenant-Colonel Q. A. Gillmore, U. S. A., Chief-Engineer David Smith, U. S. N., W. Sooy Smith, C. E., A. L. Holley, C. E., and R. H. Thurston, C. E., Secretary.

The Board has organized into standing committees to conduct special experiments and investigations, during the delay in preparing the testing machinery for the regular work of the Board, and afterward, as leisure

will permit. These investigations are expected to be made with critical and scientific accuracy, and will consist in the minute analysis of a somewhat limited number of specimens, and the precise determination of mechanical and physical properties, with a view to the detection and enunciation of the laws connecting them with the phenomena of resistance to flexure, distortion, and rupture.

The Board will be prepared to enter upon a more general investigation, testing such specimens as may be forwarded to the President of the Board, or such as it may be determined to purchase in open market, immediately upon the completion of the apparatus ordered, at which time circulars will be published giving detailed instructions relative to the preparation of specimens for test, and stating minutely the information which will be demanded previous to their acceptance.

The following is a list of the subjects to be investigated by the standing committees, as given in the circular issued by the Board: Abrasion and Wear; Armor-Plates; Chemical Research; Chains and Wire Ropes; Corrosion of Metals; Effects of Temperature; Girders and Columns; Iron, Malleable; Iron, Cast; Metallic Alloys; Orthogonal Simultaneous Strains; Physical Phenomena; Reheating and Rerolling; Steels produced by Modern Processes; Steel for Tools."

**Insulation of Lightning-Rods.**—We take from the *Journal of the Telegraph* a few valuable observations on the subject of lightning-rods. The insulation of lightning-rods, says the *Journal*, is a grave error, because the insulators to some extent arrest the flow of currents of rarefied electricity, which it is the true function of the lightning-rod to facilitate. On the other hand, the insulator amounts to nothing as a barrier against a discharge of lightning, which can either pass through it or leap the short distance between the rod and the building. The prejudice in favor of insulators arises from a misapprehension. Strictly speaking, there are no non-conductors; but that term is applied to substances which conduct very imperfectly and are subjected to violent disruptive effects when a shock of electricity passes through them. To prevent a discharge from leaving the rod and passing through the building, something more must be done than to attempt to keep it out by erecting such flimsy and insignificant barriers as insulators. The rod must be arranged so as to present points for the reception and discharge of electricity at the extremities of the building, both above and below, and the different terminations in the ground must be connected by rods lying across the roof, so that lightning can be provided with a path in an horizontal direction, which, being continuous, will be preferred to any series of detached masses of conducting matter contained within the building.

**Action of Absinthe and Alcohol.**—In an essay which received a prize from the French Academy of Sciences last December, Dr. Magnan states as follows the comparative action of absinthe and of alcohol: Whether injected into the stomach, pulmonary passages, cellular tissue, or vascular system, these two agents produce different effects. Essence of absinthe, in weak doses, causes vertigo and sudden contractions in the muscles of the anterior portion of the body; in strong doses, epileptic attacks and mental disorder. The well-known effects of alcohol are muscular debility, staggering, relaxation of the limbs, and finally comatose sleep, without any epileptic symptoms. Injected simultaneously, alcohol and absinthe, instead of neutralizing, intensify one another, and the absinthine phenomena are in part masked under the alcoholic. The substances used in the manufacture of the *liqueur absinthe*, viz., the essences of anise-seed, angelica, sweet-flag, marjoram, fennel, mint, possess no toxic action. Hence all the injurious effects of the liqueur are due purely to the wormwood. Epileptiform symptoms never follow from the use of alcohol, and they are characteristic of absinthe.

**Fish-Life and the Pollution of Rivers.**—The injurious effects on fish of the pollution of rivers with the refuse of gas-works have been very thoroughly investigated by Prof. A. Wagner, of Munich, and from his report on the subject we take the following account of some of his experiments. His method

was to put small fishes into vessels containing well-water, different amounts of gas-water being added. In water to which one per cent. of gas-water was added, the fish became at once very restless, tried to jump out, turned on their backs after they had been in the polluted water one minute, and were dead after the lapse of six minutes. With one-half per cent. gas-refuse, the fish became at once restless, floated on their backs after five minutes, and died after thirty minutes. With one-quarter per cent. gas-refuse they became restless after some time, floated on their backs in one hour, and were dead after ninety minutes. With one-tenth per cent. refuse, they at first remained quiet; one of them showed no change after three hours and a half, but died after the lapse of six hours; no change was observed in another, a small pike, after seven hours, but it was dead the next morning.

**Lightning in an Electric Clock.**—A writer in *Poggendorff's Annalen* describes some curious effects of lightning on the wires of an electric clock on a steeple in Basle. The wire, which was sheathed in gutta-percha and cotton, was torn away and lay about in pieces from four to forty inches in length. These pieces at first sight presented nothing worthy of note, but they were found to have quite lost their stiffness, and further examination showed that they consisted only of the sheath; the copper was entirely gone. The interior of the sheath was smooth, and the sheath itself was whole except in a few places at variable intervals, where there were minute ruptures. These were evidently the holes at which the copper had escaped—as some remains of the metal sticking in them showed. These remains distinctly proved, too, that the copper had been driven out, for the most part, in a molten state. This melting of the wire must have been instantaneous, for the molten copper was expelled before its heat could act upon the sheath. Another striking fact is that, in a portion of the wire which was inclosed for protection in a lead pipe, the copper was quite unchanged, while the gutta-percha had been fused in several places. Here the lead acted by retarding the electric current, and thus the wire had time to give up its heat to the sheath.

**Influence of Camphor on Plant-Growth.**—Vogel, of Munich, who has studied very closely the action of camphor on plants, says that it acts like a kind of stimulant on vegetative processes, which it accelerates and intensifies. In one of his experiments he placed a branch of flowering syringa in ordinary water, and another branch in camphor-water; in twelve hours the one drooped, while the other stood upright and even developed some of its buds. This branch did not begin to wither till after the third day. Another experiment consisted in placing in camphor-water a flowering branch of syringa which was nearly dead. In this instance the plant revived, living for some time. Similar results were obtained from experiments with seeds. Oil of turpentine was found to act like camphor. It accelerated the germinative process in seeds, but it exerted an injurious action on the after-development of the plants. Vogel remarks, in conclusion, that the process of germinating, receiving of oxygen, and giving out of carbonic acid, is identical with animal respiration. From the agreement of the vegetable processes in the early period of germination with the animal processes, it would seem to follow that stimulants would have similar effects in the two cases.

**A New Deep-Sea Thermometer.**—Dr. Neumayer recently exhibited to the Berlin Geographical Society a new apparatus for the determination of the temperature and of the currents at great depths in the ocean. The apparatus consists of an hermetically-sealed copper box, with an external appendage resembling a rudder. In the interior are a mercury thermometer and a compass, each inclosed in a glass receptacle, in which are admitted traces of nitrogen gas. A small electric battery completes the apparatus. When it is allowed to descend attached to a sounding-line, the action of the current on the rudder causes the apparatus to take an horizontal direction, thus indicating the set of the flow by the relative positions of compass-needle and rudder, while the thermometer indicates the temperature. To fix these indications, a piece of photographic paper is suitably disposed near the glass cases containing the instruments. Then at

the proper time a current of electricity is established through the gas in the receptacles, causing an intense violet light, capable of acting chemically on the paper for a sufficient length of time to photograph the shadows of the compass-needle and the mercury column. Within three minutes the operation is complete, and then the apparatus is hoisted and the paper removed.

**Absorption of Water by Growing Grain.**—M. Marie-Davy has been making some exact measurements of the quantity of water consumed by grain during its growth. He found that corn in pots, filled with earth and watered daily, consumed 1,796 grammes of water daily to produce one gramme of grain. According to this, a yield of thirty hectolitres (eighty bushels) of corn per hectare (two-fifths of an acre) would take up a quantity of water which, along with the water evaporated, forms a greater total than the amount of the average rainfall of Paris. Thus the yield of the land is limited by the amount of water supplied to the fields. M. Marie-Davy, however, points out that the quantity of water necessary to produce a given harvest is by no means absolute, but depends on the amount of useful mineral matters with which the water can be charged. To a certain extent water supplements manure, and *vice versa*. Some manures may effect a very considerable economy in the mass of water consumed.

**Vegetation as a Disinfectant.**—In a paper advocating the utilization of sewage for agricultural purposes, Dr. Alfred Carpenter says that, if a certain weight of rye-grass seed be sown in wet sand, without allowing the contact of any water which contains nitrogenous matter, the plants will grow to a certain size, that is, until they have used up all the matter contained in the seed, and then growth is, to a great extent, arrested. This has been shown experimentally by growing rye-grass under glass. All growth has been arrested for want of nourishment. On adding to the water solutions of fresh organic matter (meat-juice), the plant has at once begun to grow, and in a few days has doubled its size, while a test set of plants to which such organic matter has not been added has remained stationary. Another basin and glass cover with sand not containing rye-grass, but to which organic matter had been added, became putrid in a few days, but no such putridity appeared when the rye-grass was growing. A fourth case had put into it an amount of nitrate of ammonia corresponding to the amount estimated to be contained in the meat-juices which were used in the first case; but here the growth of the plant was by no means so luxuriant as when the living nitrogenous matter was added: although a fresh start was made, the plant soon dwindled away and died. Thus it appears that living vegetation acts as a powerful disinfectant, assimilating directly the nitrogenous principles of organic substances.

**Nutritive Value of Cocoa.**—The nutritive constituents of cocoa correspond very closely with those of beef, and largely exceed those of milk and wheaten flour: hence the importance of this substance as an article of food. In this respect it differs widely from tea and coffee, which are, perhaps, rather condiments and stimulants than foods, or flesh-formers. The following table, drawn up by Mr. John Holm, of the Edinburgh Chemical Society, shows the position of cocoa as compared with three other well-known articles of food:

| ARTICLES. | Cocoa. | Milk. | Meat (Beef). | Wheaten Flour. |
|---|---|---|---|---|
| Fat | 50.0 | 3.5 | 2.87 | 1.2 |
| Azotized substances | 20.0 | 4.0 | 20.75 | 14.6 |
| Starch | 7.0 | ... | .... | 59.7 |
| Gum | 6.0 | .... | ..... | ... |
| Sugar | .... | 4.3 | ..... | 7.2 |
| Water | 5.0 | 87.5 | 67.80 | 13.2 |
| Salts | 4.0 | 0.7 | 5.60 | 1.6 |
| Woody fibre | 4.0 | .... | ..... | .... |
| Cellulose | .... | .... | ..... | 1.7 |
| Coloring-matter | 2.0 | .... | ..... | .... |
| Ash | .... | ... | 1.60 | 0.8 |
| Extractive matters | .... | .... | 1.38 | .... |
| Theobromine | 2.0 | .... | .... | .... |
| Parts | 100.0 | 100.0 | 100.00 | 100.0 |

"Thus," observes Mr. Holm, "although one-half of the weight of cocoa consists of cocoa-butter, it still presents 20 per cent. of albuminoid material, as against 4 per cent. in milk, 20.75 in beef, and 14.6 in wheat. In addition, it contains starch, which is present neither in milk nor beef, but in smaller proportion than in wheat." The value of cocoa as a food is thus apparent, and fully justifies the high eulogiums which have been passed upon it.

**Statistics of Suicide in Prussia.**—The number of suicides occurring in the kingdom of Prussia during the four years preceding 1873 is given as follows in the official journal of the Statistical Bureau:

| SUICIDES. | 1869. | 1870. | 1871. | 1872. |
|---|---|---|---|---|
| Males | 2,570 | 2,334 | 2,183 | 2,363 |
| Females | 616 | 629 | 540 | 587 |
| Total | 3,186 | 2,963 | 2,723 | 2,950 |

From this it would appear that either the female sex is less exposed to the temptation of suicide, or resists that temptation better than the male. The table shows that the frequency of suicide increases with age. This is true with regard to the whole number of suicides, not with regard to those of each sex taken separately. Thus suicide is most frequent among males between the ages of ten and fifteen, and again between fifty and sixty, while among females it is most frequent between fifteen and twenty, and again after seventy. Of suicides, married persons constitute 452 per 1,000, unmarried, 339 per 1,000, and the remainder is made up of widows, widowers, divorced persons, etc. Mental disease is by far the most frequent occasion of suicide. Religious belief does not appear to have any marked influence. On the other hand, the influence of various avocations is very evident. The favorite modes of suicide are, in both sexes, hanging and drowning—the latter more frequent in the case of females; then by fire-arms on the part of the males, by poison on the part of the females.

**Defects of the Human Eye.**—The human eye, because it is practically achromatic, has been supposed to be absolutely so. But it is not difficult to show that the organ is not faultless in this respect. The subject was recently discussed in a lecture by Prof. H. McLeod, at the London Physical Society, and the lecturer cited many facts to show that the eye is not achromatic. Thus to short-sighted persons the moon appears to have a blue fringe. In using the spectroscope, the red and blue ends of the spectrum cannot be seen with equal distinctness without adjusting the focussing glass. A black patch of paper on a blue ground appears to have a fringed edge if viewed from even a short distance; while a black patch on a red ground, when observed under similar conditions, has a perfectly distinct margin. It is interesting to note that Wollaston considered that the colored bands of the spectrum were really divided by the black (Fraunhofer) lines, and his statement, that the red end of the spectrum does not appear to have a boundary-line "because the eye is not competent to converge the red rays properly," shows that he had very nearly, if not quite, discovered the achromatic defects of the eye. An experiment was exhibited by Prof. McLeod to show the relative distinctness of a dark line on grounds of various colors. A wire was so arranged that its shadow traversed the entire length of the spectrum, which was thrown on a screen by an electric lamp. Viewed from a short distance, the edges of the shadow appeared to be sharp at the red end, but gradually became less distinct, until at the blue end nothing but a blurred line remained.

**Infrequency of Pulse.**—A case of extraordinary infrequency of pulse was recently mentioned by Mr. Pugin Thornton, at a meeting of the Clinical Society of London. The subject was a woman, twenty-nine years of age, thin and anæmic, and suffering from severe inflammation of the larynx, for which the operation of tracheotomy was performed. Just before the operation her pulse was 40, and after it she had an epileptiform attack. She was discharged from the hospital much improved, but was readmitted soon afterward. Her pulse was then found to be beating only at the rate of 16 per minute, the pulsations being strong. The frequency increased slowly for a month, when it was 20, and soon afterward it was again 40. This was some two years ago. Her pulse is now 48, and the patient has grown stout. Normally, the number of pulsations per minute differs at different periods of life: at birth, it is about 135; at the age of seven, from 80 to 85; in adults, 70 to 75; in old age, from 50 to 65. In females, the pulse is quicker than in males.

**Ornamentation of Copper and Bronze.**—A new mode of ornamenting bronze or copper work is described as follows: After the object has received the desired form, the

drawings are made with water-colors, the body of which is white-lead. Those portions of the surface which are not painted are covered with varnish. The article is then placed in dilute nitric acid, whereby the paint is dissolved, and the surface of the metal is etched to a certain depth. The article is then washed with water, and immediately placed in a silver or gold bath, and a layer of the precious metal deposited by electricity on the exposed portions. When the latter operation is finished, the varnish is removed, and the whole surface ground or polished, so that the ornamented portion is just even with the rest of the surface. A specially fine effect is obtained by producing a black bronze of sulphuret of copper on portions of the surface between the silver ornaments. A copper vase then has three colors, black and white drawings on a red-brown ground of suboxide of copper.

**Ancestors of the Esquimaux.**—Charles E. DeRance, in one of his papers on "Arctic Geology," points out some of the many striking resemblances between the modern Esquimaux and the paleolithic man of Southern France. These two peoples, separated so widely in time and space, were alike in their artistic feelings and methods of incising, on tusks, antlers, and bones, representations of familiar objects; alike also in their habit of splitting bones for marrow, and accumulating them around their dwellings; in their disregard for the sepulchre of their dead; in their preparation of skins for clothing, and in the pattern of the needles used in sewing them together; alike also in their feeding on the musk-sheep and the reindeer, and in countless other characteristics. It is wellnigh impossible to resist Prof. Dawkins's conclusion that the Esquimaux is the descendant of paleolithic man, who retreated northward with the arctic fauna with which he lived in Europe.

**Antidote to Atropia.**—Dr. G. Rückert has made the interesting discovery that the poisonous alkaloid muscarin (extracted by alcohol from the mushroom *Amanita muscaria*) is a perfect antidote to atropia, and *vice versa*. The pupil of the eye, enlarged by atropia, is contracted by muscarin. So, too, the depression of temperature induced by subcutaneous injection of muscarin is counteracted by the other alkaloid similarly injected. The heart of a frog, whose action had ceased from thirty to sixty minutes under the influence of muscarin, had its activity restored by the exhibition of atropia. The relation of quinine to the specific poison of intermittent fevers is probably analogous to that between these two alkaloids.

## NOTES.

Correction.—Prof. Henry Wurtz corrects an error in the theory of A. McDougall, of the Manchester Literary and Philosophical Society, on the possible mode of formation of graphite, as given in our Notes for last month. As he points out, the carbon which collects in gas-retorts does not give the reactions of graphite with a mixture of chlorate of potassium and nitric acid; it is not converted into graphitic acid; therefore it is not graphite at all, and of course its formation cannot explain the formation of that mineral. It has even been shown by Berthelot that gas-retort carbon contains hydrogen, being in fact a highly-condensed hydro-carbon, or mixture of hydro-carbons.

The Aniline Manufacturing Company, of Berlin, are now producing aniline colors by Coupier's process, in which no arsenic acid is employed. Being free from arsenic, these dyes are not only fitted for coloring sweetmeats, liqueurs, syrups, and pharmaceutical preparations, but may be used in many other industrial purposes where poisonous colors would be more or less dangerous, as in the staining of paper, paper-hangings, toys, etc.

A flame burning in condensed air gradually increases in brilliancy with the compression, till at last it becomes as brilliant as the flame of phosphorus in oxygen. But, if the pressure be still further increased, the process of combustion is retarded, and the flame becomes smoky. From this it would appear that the temperature of combustion increases with the pressure up to the point of dissociation of the hydro-carbon gases of the candle. Hence the conclusion that it is an error to estimate the temperature of the sun at several millions of degrees. Sainte-Claire Deville holds that 2,000° C. is the highest possible temperature.

Schweinfurth, the distinguished African traveler, has been appointed by the Khédive Director-General of all the large collections, museums, and other scientific institutions, of Cairo.

The length of time needed for reaction in sensation has been made a subject of investigation by two German physiologists, Vintschgau and Hongschmied, with the following results: In the case of a person whose sense of taste was highly developed, the reaction-time was, for common salt, 0.159 second; for sugar, 0.1639 second; for acid, 0.1676 second; and for quinine, 0.2351 second. With a person whose taste was less acute the reaction-times were 0.595 second for salt, 0.752 second for sugar, and 0.993 second for quinine. It will be seen that in both instances for the bitter taste of quinine the reaction-time was considerably longer than for the others.

The most noteworthy circumstance connected with Captain Boyton's feat of crossing the English Channel is, not so much his having been kept afloat for so many hours, but that his body temperature was not lowered appreciably. His water-proof dress prevents the loss of animal heat, and hence, after being in the water for fifteen hours, Captain Boyton was almost as fresh and vigorous on reaching Boulogne as when he started from Dover.

An apothecary and self-styled surgeon in Liverpool, named Heap, was recently hanged for the crime of attempting to procure abortion on a young woman, and so causing her death. The jury recommended the culprit to mercy, but the authorities very commendably refused to interfere with the process of the law.

In view of the prohibitory duties imposed by the United States upon imported agricultural machinery, the British Association of Agricultural Engineers recommends manufacturers to hold aloof from the Philadelphia Exhibition. The imposition of prohibitory duties is declared to be out of harmony with the objects of international exhibitions. This advice will be adopted almost unanimously in England.

A Scientific Association has been organized in Peoria, Ill., with Dr. W. H. Chapman as president. Arrangements have been completed by the Association for a "Summer School" for the study of botany and zoölogy, the term to extend over four weeks, commencing on July 5th. The instructors will be Profs. Burt G. Wilder and J. H. Comstock, of Cornell University, and Prof. Alphonso Wood. The tuition for the term will be fifteen dollars.

The meeting of the British Association for the Advancement of Science takes place this year at Bristol, commencing Wednesday, August 25th. The President of the Association for the present year is Sir John Hawkshaw, C. E., Fellow of the Royal Society.

A donation of $25,000 for library purposes has been made to the Philadelphia Academy of Natural Sciences. The library of the Academy already contains 20,000 scientific works, but is in many respects incomplete. It is believed that with the means now at the disposal of the Academy the library can be made equal to any scientific library in the world.

Died, March 20th, Daniel Hanbury, F. R. S., F. L. S., member of the British Pharmaceutical Society. Deceased had attained distinction by his original investigations into the nature and history of drugs, and of the plants from which they are obtained. Just before his death appeared "Pharmacographia: a History of the Principal Drugs of Vegetable Origin met with in Great Britain and British India." Of this work Hanbury was joint author with Prof. Fluckiger, of Strasburg.

The committee of the Bremen Polar Expedition propose that their vessels shall coast along the eastern shore of Greenland, while the English expedition proceeds up Smith's Sound. If this arrangement is carried out, possibly these two expeditions may meet at the pole, or at all events at the northernmost portion of Greenland.

The Anderson School of Natural History, at Penikese Island, will not be opened this summer. A card from Prof. A. Agassiz states that "the applications for this summer's session have been so much reduced by the attempt to make the school partially self-supporting, that the trustees are forced, in order to save the institution from debt, to close it for the coming season. Since no assistance is to be expected from State Boards of Education, it becomes evident that the school must be carried on either by the help of the teachers for whose advantage it is intended, or by endowment. This interruption, which it is hoped may be only temporary, arises neither from lack of enthusiasm in the pupils of Penikese, nor from any want of generous interest in the naturalists who have thus far given their services to aid the enterprise."

The French Geographical Society has awarded a gold medal to the family of the late Captain Hall, in recognition of the distinguished services rendered to geographical science by that intrepid explorer.

The *Gardener's Chronicle* states, on the authority of the market-gardeners around London, that the spring just passed was the most backward known in that locality for many years.

Dr. J. Bell Pettigrew has been awarded the Goddard prize of the French Academy of Sciences for his original anatomical and physiological memoirs.

The *Sanitarian* publishes a table showing the death-rate of various cities in the United States for the month of March, from which it appears that the highest death-rate (Nashville) was 37.69 per thousand per annum, and the lowest (St. Louis) 13.37. Other cities showed the following death-rates: New York, 30.25; Philadelphia, 26.30; Brooklyn, 23.54; Chicago, 15.73; Boston, 22.67; New Orleans, 26.72; Washington, 33.36; Richmond, 26.40; Charleston, 34.50; New Haven, 19.80.

A party of Englishmen, Drs. Freeland and Nicholls, Captain Gardner, and Mr. Watt, while exploring the steep and forest-covered mountain behind the town of Rosseau, in the republic of Dominica, came upon a boiling lake about 2,500 feet above the sea-level, and two miles in circumference. When the wind cleared away for a moment the clouds of sulphurous steam with which the lake was covered, a mound of water was seen ten feet higher than the general level, and caused by ebullition. The margin of the lake consists of beds of sulphur; at the outlet is a waterfall of great height.

The twenty-fourth meeting of the American Association for the Advancement of Science will be held at Detroit, Mich., commencing on Wednesday, August 11th. The Permanent Secretary calls special attention to the meeting of the Entomological Club. It is proposed to form a subsection of Anthropology at the coming meeting of the Association. Officers of this year's meeting: President, Prof. J. E. Hilgard; Vice-President, Section A, Prof. H. A. Newton; Section B, Prof. J. W. Dawson; chairman, Chemical Subsection, Prof. S. W. Johnson.

M. Le Verrier, Director of the Paris Observatory, transmits twice daily to the principal ports of France forecasts of the probable weather for the ensuing twelve hours. The present system does not include signals to give warning of storms. The telegrams are posted up in some public place.

It is suggested to form an artificial isthmus between France and England, leaving a narrow space in the centre for the passage of ships. The expense would not be much greater than in boring a tunnel, and the advantages in some respects greater.

A newspaper paragraph gives this instance of community of disease in man and animals. A large Newfoundland dog, belonging to a Mr. Wallace, of Upton, Mass., contracted measles from the children of a Mr. Walker, and died of the disease. The dog exhibited all the symptoms of measles as seen in human beings, and under medical treatment was convalescing, when he ran out in the snow, was chilled, and died.

A club has lately been formed in this country for the circulation among its members, by way of the United States mails, of microscopic objects. Applications for membership should be made to the secretary of the club, Rev. A. B. Hervey, 10 North Second Street, Troy, N. Y. Those only are eligible as members who are accustomed to work with the microscope, and who can contribute to the usefulness of the club by sending good objects for examination.

At the Louisville meeting of the American Medical Association, S. D. Gross, M. D., of Philadelphia, avowed himself an advocate of bloodletting for many diseases, especially those of an inflammatory character. He predicted that phlebotomy would again come to be recognized as a therapeutic agent, but that it would not be practised indiscriminately.

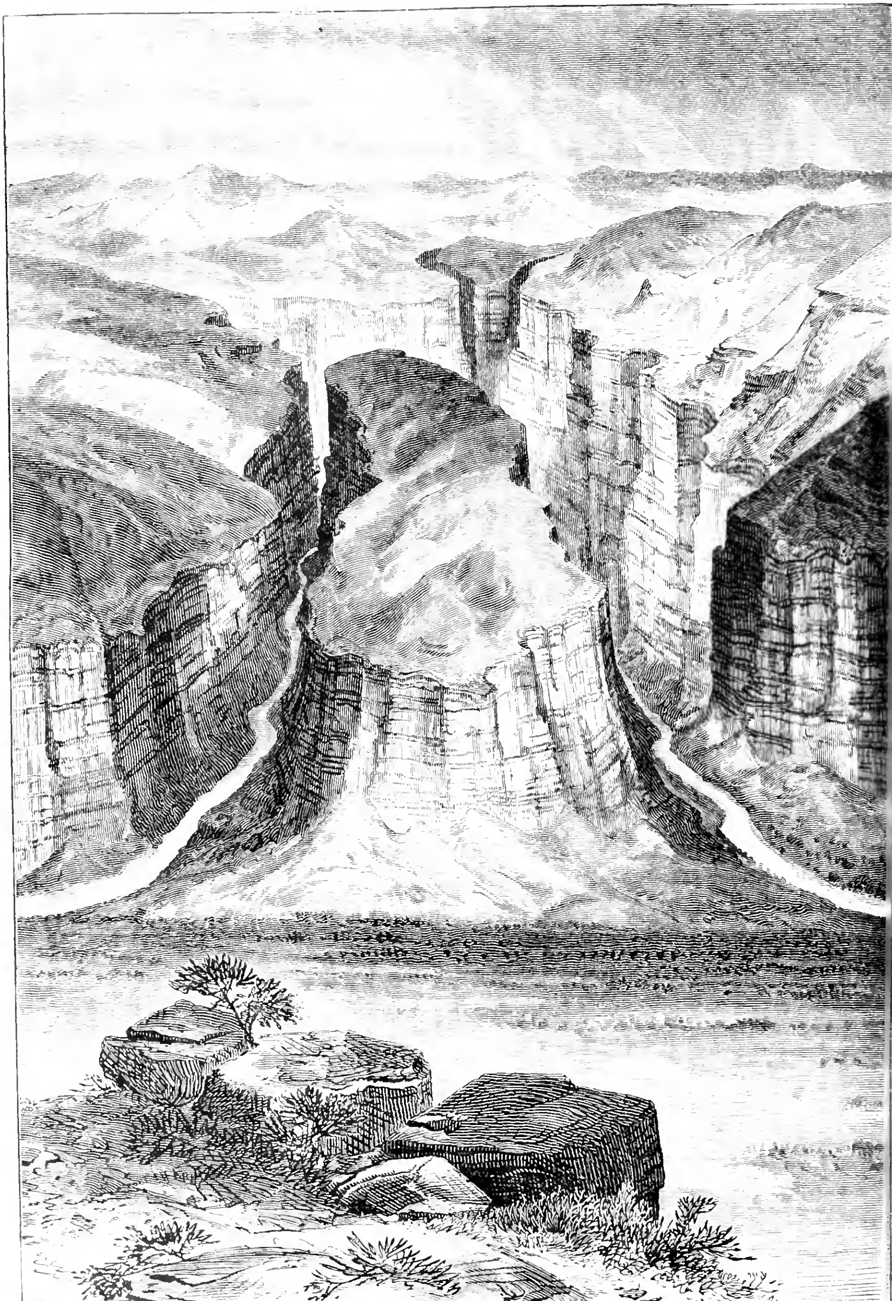
Pettenkofer has shown that a cubic foot of soil contains one-third of a cubic foot of air. Now, according to Boussingault, the amount of carbonic acid in this air is much more than that in the atmosphere. He found that in a field recently manured it amounted to 221 parts in 10,000 of air; in a vineyard, 96; forest-land, 86; loamy subsoil, 82; sandy subsoil, 24; garden-soil, 36.

The title of the society known as the New York Lyceum of Natural History has been changed. It will henceforward be known as the New York Academy of Sciences.

A correspondent of the Department of Agriculture writes that a decoction of tansy is always effectual in killing bots. He gives the tansy in the morning to a horse infested with bots, and in the evening a dose of salts; the bots die, and pass out with the excretions.

Black silks are very commonly "weighted" with foreign substances to the amount of 100, 200, and 300 per cent. This increase in weight is caused by treatment with salts of iron and astringents, salts of tin and cyanides. In fact, what is sold as silk is a mere agglomeration of heterogeneous matters, held temporarily together by a small portion of silk.

It is stated by Paul Perny, formerly a pro-vicar apostolic in China, that the Emperor Kien-Lung, who lived upward of a century ago, drew up the plan of a general encyclopædia of human knowledge, the publication of which still goes on. Nearly 100,000 volumes of this work have appeared, and there remain 60,000 volumes to be published! M. Perny further states that the Chinese have encyclopædias of more than 300 volumes on agriculture, horticulture, pisciculture, etc.



HORSESHOE CAÑON.

THE

# POPULAR SCIENCE MONTHLY.

**AUGUST, 1875.**

## PHYSICAL FEATURES OF THE COLORADO VALLEY.[1]

By Major J. W. POWELL.

### I. *Mountains and Valleys.*

THE topographical features of the valley of the Colorado, or the area drained by the Colorado River and its tributaries, are, in many respects, unique, as some of these features, perhaps, are not reproduced, except to a very limited extent, on any other portion of the surface of the globe. Mountains, hills, plateaus, plains, and valleys, are here found, as elsewhere throughout the earth; but, in addition to these topographic elements in the scenic features of the region, we find buttes, outlying masses of stratified rocks, often of great altitude, not as dome-shaped or conical mounds, but usually having angular outlines; their sides are vertical walls, terraced or buttressed, and broken by deep, reëntering angles, and often naked of soil and vegetation.

Then we find lines of cliffs, abrupt escarpments of rock, of great length and great height, revealing the cut edges of strata swept away from the lower side. Thirdly, we find cañons, narrow gorges, scores or hundreds of miles in length, and hundreds or thousands of feet in depth, with walls of precipitous rocks.

In the arid region of the Western portion of the United States, there are certain tracts of country which have received the name of *Mauvaises Terres*, or Bad Lands. These are dreary wastes—naked hills, with rounded or conical forms, composed of sand, sandy clays, or fine fragments of shaly rocks, with steep slopes, and, yielding to the pressure of the foot, they are climbed only by the greatest toil, and it is a labor of no inconsiderable magnitude to penetrate or cross such a district of country. The steep hills are crowded together, and the water-ways separating them are deep *arroyas*. Where the mud-

[1] From "Report on United States Geological and Geographical Survey of the Territories. Second Division." Major J. W. Powell in charge.

rocks, or sandy clays and shales, of which the hills are composed, are interstratified with occasional harder beds, the slopes are terraced; and when these thinly-bedded, though harder, rocks prevail, the out-

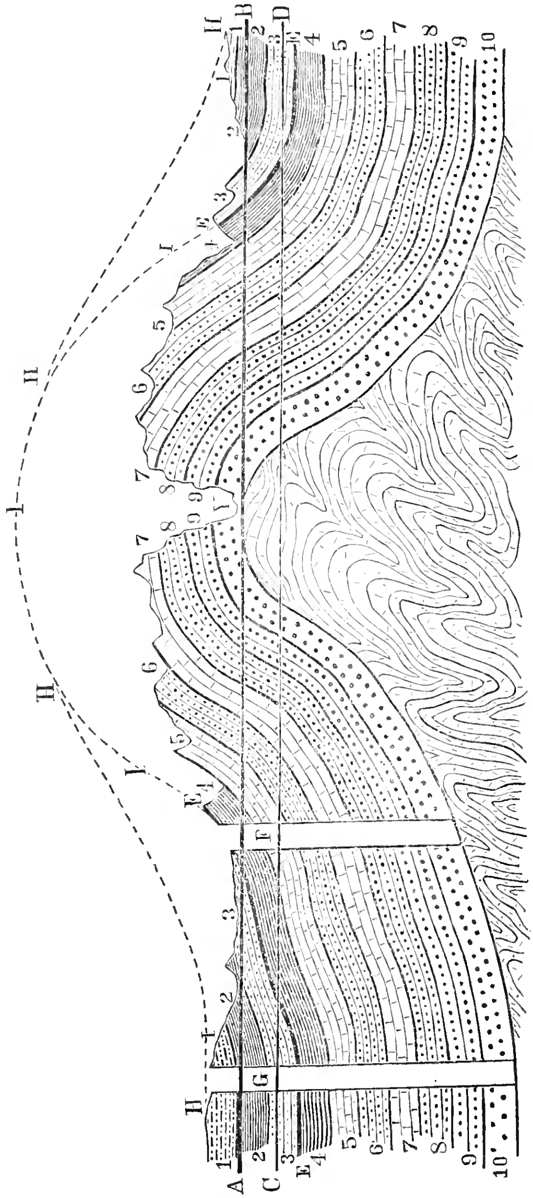


Fig. 1.—Generalized Section through the Uinta Mountains from North to South.

lines of the topography are changed, and present angular surfaces, and give rise to another type of topographic features, which I have denominated Alcove Lands.

The agencies and conditions under which all of these features have been formed deserve mention, and in this and following chapters I shall briefly discuss this subject, in a manner as free from technical terms as will be consistent with accurate description.

The discussion will by no means be exhaustive, and I hope hereafter to treat this subject in a more thorough manner. In view of these facts, I shall not attempt any logical classification of the elements of the topography, nor of the agencies and conditions under which they were produced; but, commencing at the north, at the initial point of the exploration, I shall take them up in geographic order, as we proceed down the river.

Bad Lands and Alcove Lands north of the Uinta Mountains.—The area north of the Uinta Mountains embraced in the survey is but small. Through the middle of it runs Green River, in a deep, narrow valley, the sides or walls of which sometimes approach so near to each other, and are so precipitous, as to form a cañon.

The general surface of the country, on the north of this district, is about 1,000 feet above the river, with peaks, here and there, rising a few hundred feet higher; but south, toward the Uinta Mountains, this general surface, within a few miles of the river, gradually descends, and at the foot of the mountains we find a valley on either side, with a direction transverse to that of the course of Green River, and parallel to the mountain-range.

To the north, the water-ways are all deeply eroded; the permanent streams have flood-plains of greater or lesser extent, but the channels of the wet-weather streams, i. e., those which are dry during the greater part of the year, are narrow, and much broken by abrupt falls.

The rocks are the sediments of a dead lake, and are quite variable in lithologic characteristics. We find thinly-laminated shales, hard limestones, breaking with an angular fracture, crumbling Bad-Land rocks, and homogeneous, heavily-bedded sandstones.

The scenic features of the country are alike variable. On the cliffs about Green River City, towers and buttes are seen as you look from below, always regarded by the passing traveler as strange freaks of Nature. The limestones, interstratified with shales, give terraced and buttressed characteristics to the escarpments of the cañons and narrow valleys.

Immediately south of Bitter Creek, on the east side of Green River, there is a small district of country which we have called the Alcove Land. On the east it is drained by Little Bitter Creek, a dry gulch much of the year. This runs north into Bitter Creek, a permanent stream, which empties into the Green. The crest of this water-shed is an irregular line, only two to four miles back from the river, but usually more than 1,000 feet above it, so that the waters have a rapid descent, and every shower-born rill has excavated a deep, narrow

channel, and these narrow cañons are so close to each other as to be separated by walls of rock so steep, in most places, that they cannot be scaled, and many of these little cañons are so broken by falls as to be impassable in either direction.

The whole country is cut, in this way, into irregular, angular blocks, standing as buttresses, benches, and towers, about deep water-ways and gloomy alcoves.

The conditions under which the cañons have been carved will be more elaborately discussed hereafter.

To the west of Green River, and back some miles, between Black's Fork and Henry's Fork, we have a region of buff, chocolate, and lead-colored Bad Lands. This Bad-Land country differs from the Alcove Land, above mentioned, in that its outlines are everywhere beautifully rounded, as the rocks of which it is composed crumble quickly under atmospheric agencies, so that an exposure of solid rock is rarely seen; but we have the same abrupt descent of the streams, and the same elaborate system of water-channels. Here we have loose, incoherent sandstones, shales, and clays, carved, by a net-work of running waters, into domes and cones, with flowing outlines. But still there is no vegetation, and the loose earth is naked. Occasionally, a thin stratum of harder rock will be found. Such strata will here and there form shelves or steps upon the sides of the mountains.

Traces of iron, and rarer minerals, are found in these beds, and, on exposure to the air, the chemical agencies give a greater variety of colors, so that the mountains and cones, and the strange forms of the Bad Lands, are elaborately and beautifully painted; not with the delicate tints of verdure, but with brilliant colors, that are gorgeous when first seen, but which soon pall on the senses.

The Uinta Mountains.—To the west of Green River stand the Wasatch Mountains, a system of peaks, tables, and elevated valleys, having a northerly and southerly direction, nearly parallel to the river. The range known as the Uinta Mountains stands at right angles to the Wasatch, extending toward the east, and no definite line of division can be noticed. The Wasatch is a great trunk, with a branch called the Uinta. Near the junction, the two ranges have about the same altitude, and the gulches of their summits are filled with perpetual snow; but, toward the east, the Uinta peaks are lower, gradually diminishing in altitude, until they are lost in low ridges and hills. Through this range Green River runs, and a series of cañons forms its channel.

To a person studying the physical geography of this country, without a knowledge of its geology, it would seem very strange that the river should cut through the mountains, when apparently it might have passed around them to the east, through valleys, for there are such along the north side of the Uintas, extending to the east, where the mountains are degraded to hills; and, passing around these, there

are other valleys, extending to the Green, on the south side of the range. Then, why did the river run through the mountains?

The first explanation suggested is, that it followed a previously-formed fissure through the range; but very little examination will

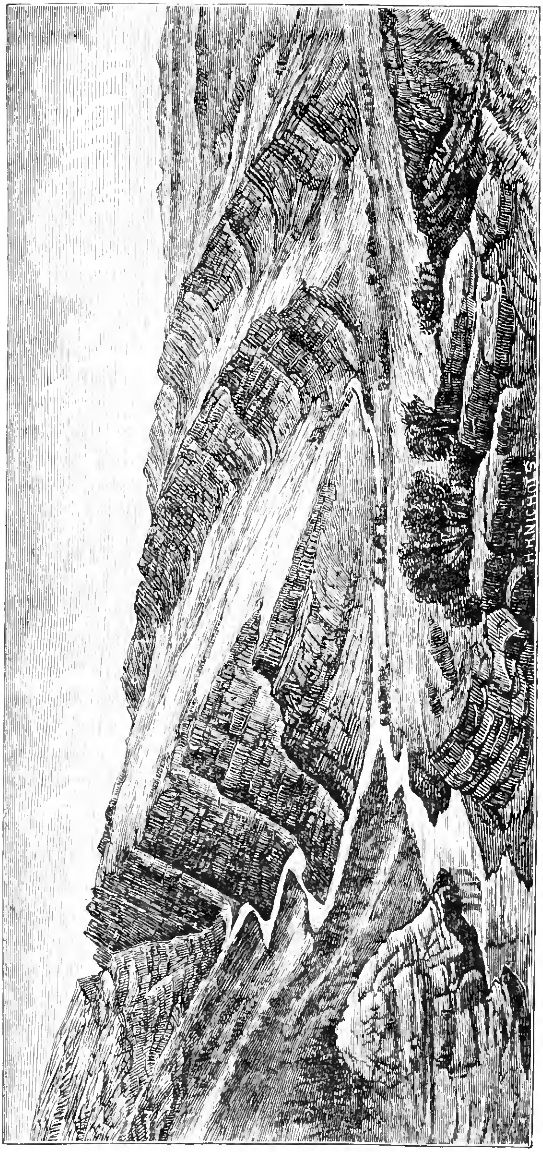



FIG. 2.—NORTHERN SLOPE OF THE UINTA MOUNTAINS, SHOWING RED CAÑON AND HOG'S BACK, WITH INTERVENING VALLEYS.

show that this explanation is unsatisfactory. The proof is abundant that the river cut its own channel; that the cañons are gorges of corrasion. Again, the question returns to us, Why did not the stream

turn around this great obstruction, rather than pass through it? The answer is, that the river had the right of way; in other words, it was running ere the mountains were formed: not before the rocks, of which the mountains are composed, were deposited, but before the formations were folded, so as to make a mountain-range.

The contracting or shriveling of the earth causes the rocks near the surface to wrinkle or fold, and such a fold was started athwart the course of the river. Had it been suddenly formed, it would have been an obstruction sufficient to turn the water in a new course to the east, beyond the extension of the wrinkle; but the emergence of the fold above the general surface of the country was little or no faster than the progress of the corrasion of the channel. We may say, then, that the river did not cut its way *down* through the mountains, from a height of many thousand feet above its present site; but, having an elevation differing but little, perhaps, from what it now has, as the fold was lifted, it cleared away the obstruction by cutting a cañon and the walls were thus elevated on either side. The river preserved its level, but mountains were lifted up; as the saw revolves on a fixed pivot, while the log through which it cuts is moved along. The river was the saw which cut the mountains in two.

Recurring to the time before this wrinkle was formed, there were beds of sandstone, shale, and limestone, more than 24,000 feet in thickness, spread horizontally over a broad stretch of this country. Then the summit of the fold slowly emerged, until the lower beds of sandstone were lifted to the altitude at first occupied by the upper beds, and if these upper beds had not been carried away, they would now be found more than 24,000 feet above the river, and we should have a billow of sandstone, with its axis lying in an easterly and westerly direction, more than 100 miles in length, 50 miles in breadth, and over 24,000 feet higher than the present altitude of the river, gently rounded from its central line above to the foot of the slope on either side. But as the rocks were lifted, rains fell upon them and gathered into streams, and the wash of the rains and the corrasion of the rivers cut the billow down almost as fast as it rose, so that the present altitude of these mountains marks only the difference between the elevation and the denudation.

It has been said that the elevation of the wrinkle was 24,000 feet, but it is probable that this is not the entire amount, for the present altitude of the river, above the sea, is nearly 6,000 feet, and when this folding began we have reason to believe that the general surface of this country was but slightly above that general standard of comparison.

Then there were down-turned as well as up-turned wrinkles, or, as the geologist would say, there were synclinal as well as anticlinal folds. Had there been no degradation of the fold, there would have been a bed of rock turned over its summit 24,000 feet above the pres-

ent level of the river. Now that bed is gone from the mountains, yet it can be seen turned up on edge against the flanks of the mountains, dipping under the beds of rocks found still farther out from the range. Follow it down, and doubtless we could trace it to a depth much below the level of the sea. While the folds were forming, the upturned flexures were cut down, and the troughs in the down-turned flexures were filled up, and we have more than 8,000 feet of these later sediments to the north of the Uinta Mountains.

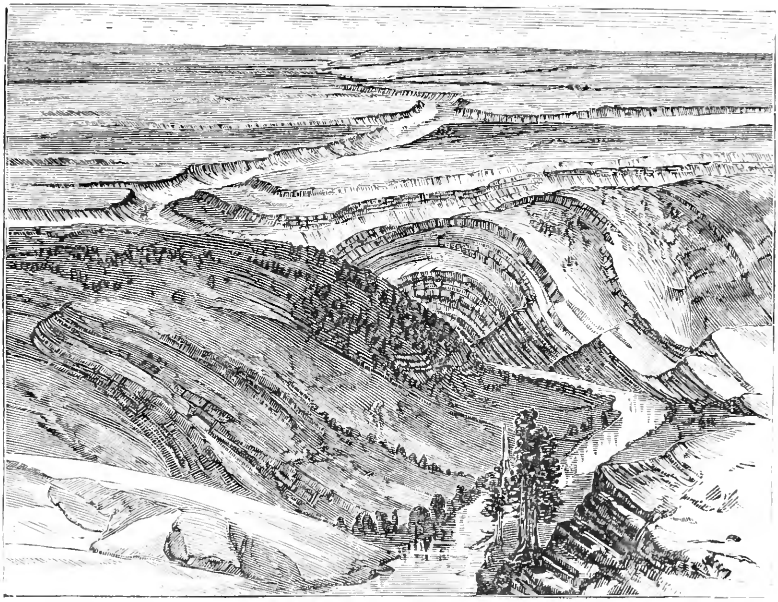


Fig. 3.—Diaclinal Valley.

It will thus be seen that the upheaval was not marked by a great convulsion, for the lifting of the rocks was so slow that the rains removed the sandstones almost as fast as they came up. The mountains were not thrust up as peaks, but a great block was slowly lifted, and from this the mountains were carved by the clouds—patient artists, who take what time may be necessary for their work.

We speak of mountains forming clouds about their tops: the clouds have formed the mountains. Lift a district of granite, or marble, into their region, and they gather about it, and hurl their storms against it, beating the rocks into sands, and then they carry them out into the sea, carving out cañons, gulches, and valleys, and leaving plateaus and mountains embossed on the surface.

Instead of having a rounded billow, we have an irregular table, with beds dipping to the north, on the north side of the axis, and to the south, on the south side, and in passing over the truncated fold we pass over their upturned edges.

Go out on the flank of the fold, and find the bed of rock which would form the summit of the great wrinkle, had there been no erosion, and there sink a shaft 24,000 feet, and you will be able to study a certain succession of beds of sandstones, shales, and limestones. Go two or three miles farther from the mountains, and sink a shaft; the first 8,000 feet or more will be through sandstones and shales, unlike those seen in the first section; then you will strike the summit of the first section. Continuing down for 24,000 feet, the first will be reproduced, stratum for stratum. Now start on either side of the fold, and cross to its centre; and you will pass over the same series of strata in the same order as you would in descending the first-mentioned shaft, and in the second also, below the upper 8,000 feet. Now pass again from the centre to the flank of the fold, in either direction, and you can study the same rocks in the same order as you would in ascending these shafts. It will thus be seen that in these truncated wrinkles we are enabled to study geological formations without descending into the depths of the earth.

Fig. 1 has been constructed for the purpose of graphically expressing some of the important facts observed in the great Uinta Fold. In this, the beds are seen to turn up in a great flexure, and to be cut away above, the higher beds more than the lower; thus 4, 4–4, 4, has been cut away much more than 5, 5–5, 5; and 10, 10–10, 10 has suffered much less erosion than the beds above it. The only place where the water has carried it away is at *Y*, the bottom of the cañon.

In this diagram, the line *A–B* represents the lowest line of observation, as exhibited in the bed of the river. All below this line is theoretical. The line *C–D* represents the level of the sea. The stratum *E*, *E–E*, *E* was the last deposited antecedent to the commencement of the emergence of the summit of the fold. Had there been no erosion of the fold, the beds intervening between the broken line *I*, *I*, *I* (which is a continuation of the lines *E*, *E–E*, *E*), and the irregular line which represents the surface of the country, cutting the edges of the eroded beds, and passing through the lowest, No. 10, at *Y*, would still be found, but they have been carried away.

The diagram does not properly represent the entire amount of erosion, from the fact that the vertical scale is exaggerated, and the beds have been extended beyond their proper limits, for the purpose of representing more clearly other facts of interest.

It will be seen that in passing along the line *A–B* (the bottom of the river-channel), from the shaft *F* to the bottom of the cañon *Y*, we are able to observe the beds 4, 5, 6, 7, 8, 9, 10, in the same order that we would in descending the shaft *F*. The beds 1–1, 2–2 have been deposited since the emergence of the summit of the fold, and hence never extended quite across it; yet the lower members of these beds, doubtless, at one time extended much farther up on the flanks of the fold. They have been cut away, however, as represented in the dia-

gram. Let the lines *H*, *H–H*, *H*, represent the limit of the continuation of these beds. In the shaft *G* these beds also are exposed above those seen in shaft *F*.

The altitude of the rocks above the line of observation (*A*, *B*) is exaggerated about five times. If they were reduced to one-fifth, the proportion between the rocks seen in the various escarpments of these mountains, and those carried away below the broken lines, would be properly represented.

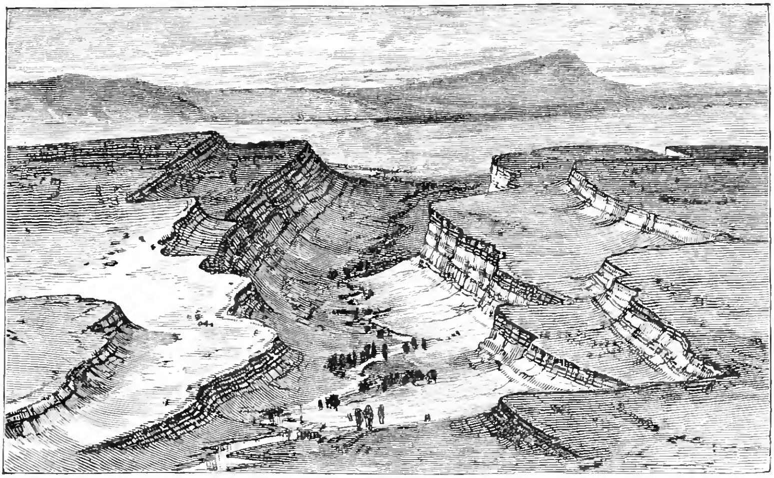


FIG. 4.—A CATACLINAL VALLEY

By sinking a shaft, only a little surface along the edge of the strata could be seen; but on the sides of the fold they are exposed for many miles, and often the top or bottom is cleared off for a great space, revealing even the ripple-marks of the ancient sea, or rounded impressions of rain-drops which fell in that elder time; or the sands have buried shells and bones of ancient animals, and they are still encased in the rock; and even impressions of leaves that were buried in the mud can yet be seen in such a fine state of preservation that you can trace their delicate veins.

In speaking of the great upheaval of rocks from which the Uinta Mountains are carved, I have spoken of wrinkling and folding, as if the rocks were always flexed; but these displacements are sometimes attended with fractures, on one side of which the rocks are upheaved, or thrown down on the other. Such displacements are called faults. Faults like these are seen in many places in the Uinta Mountains; one great one, on the north side, the throw of which is nearly 20,000 feet, and many others are found of lesser magnitude.

In speaking of elevation and depression by faulting or folding, it must be understood that reference is made to a change of altitude in

relation to the surface of the sea, so that upheaval or throw is only relative to this general standard of comparison. But during the geological ages represented in the folding and carving of the Uinta Mountains, it is possible the level of the sea itself has been changed by the shrinking of the earth, and a part, at least, of the apparent upheaval above mentioned may be accounted for by a depression of the formations in synclinal folds, and the letting down of broad areas of the earth's surface by lateral contraction exhibited in corrugation.

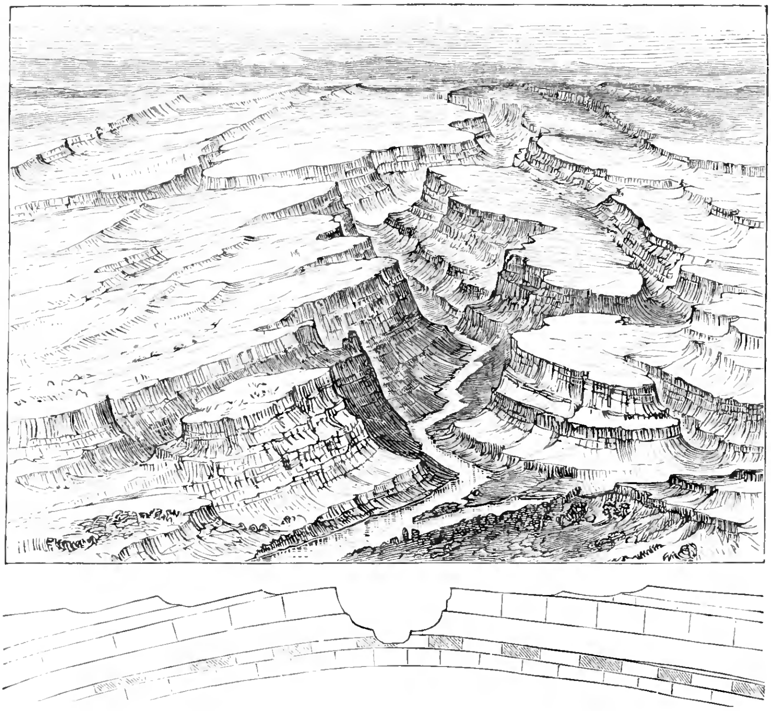


Fig. 5.—An Anticlinal Valley, with Section.

It has already been said that the cutting off of the fold has left the upturned edges of the formations exposed to view. Some of these beds are quite hard, others are composed of very soft material; so that there are alternating beds of harder and softer rocks running in an easterly and westerly direction, both on the north and south side of the range. The soft rocks, yielding much more readily to atmospheric degradation, have been washed out in irregular valleys, between intervening ridges of harder rock, so that we have a series of nearly parallel valleys, and also a series of intervening parallel ridges, and both valleys and ridges are approximately parallel to the range. But, as the great fold of the Uinta Mountains is greatly complicated

by minor oblique and transverse flexures, while the general direction of these ridges is as described, they are turned back and forth from these lines in gentle or abrupt curves. These ridges are sometimes low mountain-ranges.

So, if we approach these mountains from either direction, north or south, we first meet with ridges, or, as they are usually called in the Western country, hog-backs. In many places these are so steep as to form a complete barrier to progress.

Usually the slope away from the side of the mountain corresponds above with the dip of the rock, and is gentle or steep, as the dip is lesser or greater. The side of the hog-back, next to the mountain, is composed of the cut edges of the strata, and varies greatly with the texture of the rocks; but usually it is steep or broken, sometimes buttressed, sometimes terraced, sometimes columned and fluted.

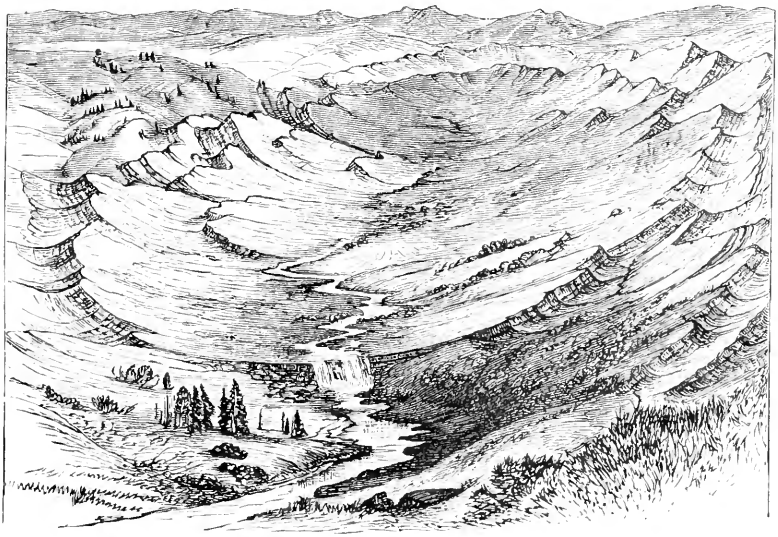


FIG. 6.—A SYNCLINAL VALLEY.

On the south side of the Yampa Plateau, near the head of Cliff-Creek Valley, there is an abrupt, oblique flexure, on the side of the great fold, by which the rocks are turned up, so as to stand vertically. In the rocks at this place there are two very hard conglomerates; the intervening strata are soft sandstones and marls, and have been carried away, and the conglomerates stand as vertical walls, 30 or 40 feet in thickness, 50 to 300 feet in height, and several miles in length, and between these is a broad avenue, or narrow valley, beset with ragged bowlders of conglomerate.

The drainage of these narrow valleys between the hog-backs is not always along their lengths, but the water is sometimes carried by channels crossing them and cutting through intervening ridges; hence

there are numbers of transverse streams and wet-weather channels running across valleys and through ridges.

Now, if the great axis of the Uinta Fold was everywhere the summit of a water-shed, we should find the streams heading along that irregular line running off to the flank of the fold on either side; but, as the fold is bisected by Green River, some of the minor water-courses, especially those near the river, and those near the centre of the fold, follow the strike of the rocks directly into that stream. On the north side, some head back near the summit of the fold, and run to the north, crossing the hog-backs in a direction with the dip, and then turn, at the foot of the mountains, and run into the Green, where the waters take a general southerly direction. Others, again, head back on the hog-backs, or even beyond them, on the plains and the Bad Lands to the north, and cut quite through the hog-backs and mountains in a direction against the dip of the rocks, and empty into the Green. This is especially true where the river has its easterly and westerly direction through Brown's Park. On the other side of the range, streams head high up in the mountains, and cut directly or obliquely against the upturned edges of the strata, and run in a general direction with the dip of the strata until they reach the long valleys between hog-backs; then down these valleys they turn, sometimes cutting through intervening ridges, until they find their way into the Green, where they are turned to the south, away from the mountain.

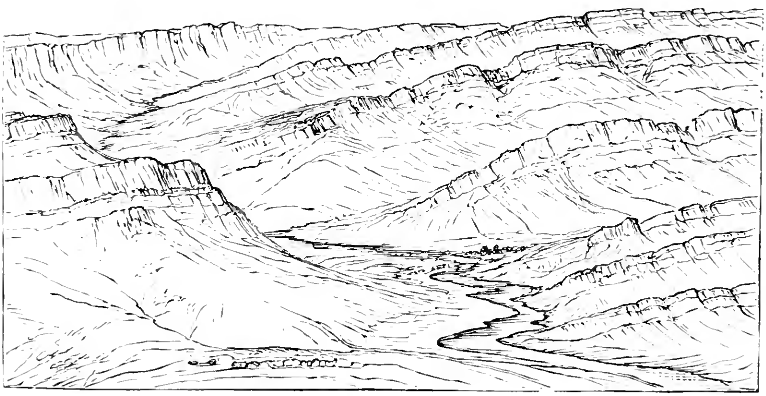


Fig. 7.—An Anaclinal Valley.

It will thus be seen that the relation of the direction of the streams to the dip of the rocks is very complex, and, for convenience of description, I have elsewhere classified these valleys, on the basis of these relations, in the following order:

Order 1.—*Transverse* valleys, having a direction at right angles to the strike.

ORDER 2.—*Longitudinal* valleys, having a direction the same as the strike.

Of the first order, three varieties are noticed:

*a*, *diaclinal*, those which pass through a fold. (Fig. 3.)

*b*, *cataclinal*, valleys that run in the direction of the dip. (Fig. 4.)

*c*, *anaclinal*, valleys that run against the dip of the beds. (Fig. 7.)

Of the second order, we have, also, three varieties:

*A*, *anticlinal* valleys, which follow anticlinal axes. (Fig. 5.)

*B*, *synclinal* valleys, which follow synclinal axes. (Fig. 6.)

*C*, *monoclinal* valleys, which run in the direction of the strike between the axes of the fold—one side of the valley formed of the summits of the beds, the other composed of the cut edges of the formation. (Fig. 8.)

Many of the valleys are thus simple in their relations to the folds; but, as we may have two systems of displacements, a valley may belong to one class, in relation to one fold, and to another in its relation to a second. Such we designate as *complex* valleys.

Again, a valley may belong to one class in one part of its course and to another elsewhere in its course. Such we designate as *compound* valleys. It will be further noticed that valleys may have many branches, but, in relegating a valley to its class, we consider only the stem of the valley proper, and not its branches.

A great diversity in the features of all these valleys is observed. Most of these modifications are due to three principal causes: First, a greater or lesser inclination of the rocks. Second, the texture of the beds—that is, their greater or lesser degree of heterogeneity. The third class of modifying influences is found in the eruptive beds.

The last-mentioned agencies are not found in the region under immediate discussion.

The explanation of the cañons of Green River will assist us in understanding the origin of the lateral valleys and cañons. The streams were there before the mountains were made; that is, the streams carved out the valleys, and left the mountains. The direction of the streams is indubitable evidence that the elevation of the fold was so slow as not to divert the streams, although the total amount of elevation was many thousands of feet. Had the fold been lifted more rapidly than the principal streams could have cut their channels, Green River would have been turned about it, and all the smaller streams and water-ways would have been cataclinal.

Thus it is that the study of the structural characteristics of the valleys and cañons teaches us, in no obscure way, the relation between the progress of upheaval and that of erosion and corrasion, showing that these latter were *pari passu* with the former, and that the agencies of Nature produce great results—results no less than the carving of a mountain-range out of a much larger block lifted from beneath

the sea; not by an extravagant and violent use of power, but by the slow agencies which may be observed generally throughout the world, still acting in the same slow, patient manner.

There are yet some interesting facts to be observed concerning these inter-hog-back valleys. Their floors are usually lower than the general surface farther away from the mountains. There seem to be two causes for this: The great fold having been lifted and truncated prior to the exposure of the rocks farther away from the mountains, its strata present their edges, instead of their upper surfaces, to the down-falling rain, and the softer beds are not so well shielded by the harder. Erosion hence progresses more rapidly than where the beds are approximately horizontal.

Again, the mountains, with peaks among the clouds, condense their moisture, and a greater quantity of rain falls on them, or in their vicinity. The region of country adjacent to the mountains re-

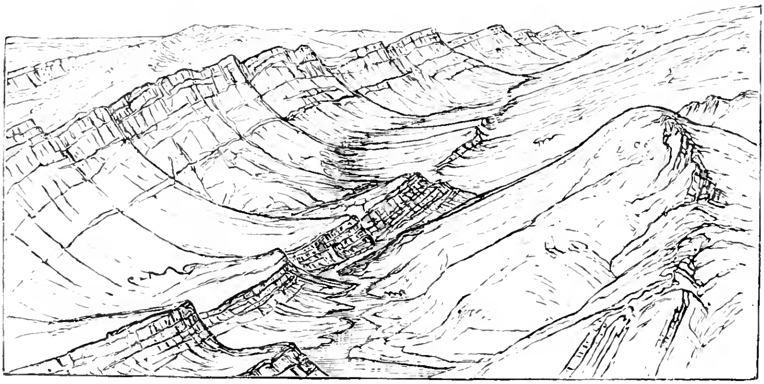


Fig. 8.—Monoclinal Valley.

ceives a portion of this extra rainfall, so that this dynamic agency increases from the plains to the summits of the mountains, probably in some direct ratio. This increase of the eroding agency, and the greater exposure of the soft beds, probably account for the fact that the lowest country is at the foot of the mountains.

There is a limit to the effect of these conditions, for it should be observed that no valley can be eroded below the level of the principal stream, which carries away the products of its surface degradation; and where the floor of such a valley has been cut down nearly to the level of such a stream, it receives the *débris* of the adjacent cliffs and mountains, and in this way the rocks composing the floor are usually masked, to a greater or lesser extent. The same topographic facts under like conditions, are found on the eastern slope of the Rocky Mountains, in Colorado Territory, and the valleys which run into the South Platte from the south, between the hog-backs, are lower than

the *mesas* and plateaus farther away from the mountains, but not lower than the flood-plain of the river.

I have endeavored above to explain the relation of the valleys of the Uinta Mountains to the stratigraphy, or structural geology, of the region, and, further, to state the conclusion reached, that the drainage was established antecedent to the corrugation or displacement of the beds by faulting and folding. I propose to call such valleys, including the orders and varieties before mentioned, *antecedent valleys.*

In other parts of the mountain-region of the West, valleys are found having directions dependent on corrugation. I propose to call these *consequent valleys.* Such valleys have been observed only in limited areas, and have not been thoroughly studied, and I omit further discussion of them.

In many cases, there can be no doubt that the present courses of the streams were determined by conditions not found in the rocks through which the channels are now carved, but that the beds in which the streams had their origin, when the district last appeared above the level of the sea, have been swept away. I propose to call such *superimposed valleys.* Thus the valleys under consideration, if classified on the basis of their relation to the rocks in which they originated, would be called *consequent valleys ;* but, if classified on the basis of their relation to the rocks in which they are now found, would be called *superimposed valleys.*

# THE FORM OF LIGHTNING-RODS.

By Prof. JOHN PHIN.

THE season when the attention of the public will be directed to protection from lightning is now approaching, and it is of the utmost importance that correct views in regard to the construction and erection of lightning-rods should prevail. We have in this country a class of men who have devoted themselves to the business of making money out of the fears which thunder and lightning inspire, and it unfortunately happens that the majority of these men care more for the money which they obtain than for the actual protection which they afford to their customers. To them, complicated arrangements, that can be defended with any show of reason, are a most important matter, for, on the ground of greater cost and efficiency, a more liberal harvest is obtained. In this connection there has been no more fertile source of imposition than the fallacy that lightning travels only on the surface of metallic conductors, for it has led to the construction of lightning-rods of which the cross-sections are stars, tubes, and all sorts of complicated devices. A recent note in The Popular Sci-

ENCE MONTHLY, translated from the *Comptes Rendus*, indorses this view, and, as no editorial protest has been added, it may have a tendency to mislead many. Let us, therefore, consider the facts in the case.

In looking up the history of this subject, the first mistake that we meet is the confounding of *static* with *dynamic*[1] electricity, or rather an utter ignorance of what static electricity is. The author of the note to which we have referred evidently supposes that all electricity produced by the ordinary frictional machine is *static*—which most assuredly is not the case. In making this mistake, however, he is not by any means alone. Dozens of writers have committed the same error, and it is not long since a medical man wrote a book on the curative powers of static, as distinguished from dynamic, electricity, while any physicist would have told him that in the entire volume there was not a single case described in which static electricity was used! Whenever electricity is in motion, that is to say, when it is flowing along a conductor, it is *dynamic*, no matter from what source it may be obtained. When at rest—that is, when it is in equilibrium—it is *static*. Dynamic electricity may be produced by the ordinary plate or cylinder machine; static electricity may have its origin in a voltaic battery.

Knowing that electricity at rest always tends to diffuse itself on the surface, in fact, that it always *confines* itself to the surface, it became, at an early period, a question whether electricity in motion did not follow the same law. Pouillet determined the question in a very ingenious manner. He took a cylindrical wire of a certain size and measured the resistance which it offered to a current of electricity. He then rolled the wire out flat and measured the resistance again; it was found to be the same, although it is evident that the extent of the surface of the conductor was by this means greatly increased. Other experimenters have determined the question by different methods, but always with the same result. The committee of the French Academy, which included Becquerel, De la Rive, Pouillet, and others, adopted a solid square bar as the best form for lightning-rods; and Sir William Snow Harris, though often quoted as favoring rods which present a large surface, says: "Provided the *quantity* of metal be present, the form under which we place it is evidently of no consequence to its conducting powers, since it would be absurd to suppose that a mass of metal, under any form, did not conduct electricity in all its particles; indeed, we know that it does so."

In attempting to determine this question, Pouillet and others seem always to have used electricity produced by a voltaic battery; and

[1] We give to the terms *static* and *dynamic* the old meanings, as evidently does the writer under review. According to the new definitions suggested and advocated by Profs. Thomson and Tait, dynamics includes statics. The point is one which does not affect the main question, however.

although, to the mind of every scientific physicist, such experiments are conclusive, the objection has been raised that they do not fairly determine the case for electricity of such high tension as lightning. To meet such objections, the writer of this article, many years ago, instituted the following experiments:

Take a strip of gold-leaf half an inch wide, and two or three inches long; pass through it a moderate charge from a six-jar electrical battery, and it will be entirely burned up. The circumference of the gold in this case is one inch, and this, of course, is the measure of the surface. Now, take a gold wire one-sixteenth of an inch in diameter, and pass through it the most powerful charge that can be obtained from the same battery; the wire will remain unaffected, although it presents but one-fifth the surface.

The difference between the action of static electricity and electricity in motion is very well shown by the following simple experiment: Take a large Leyden jar, one of say two gallons measurement, having the usual knob and other arrangements, as shown in the figure. In the wooden cover insert a glass tube, carrying at its upper extremity

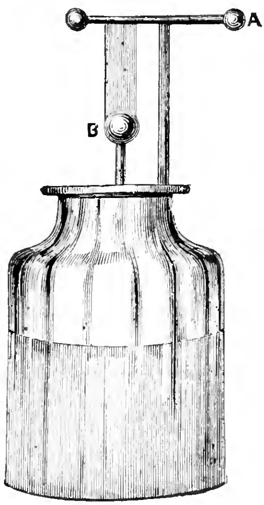



Illustration of the Effects of Static and Dynamic Electricity.

a wire lying horizontally across it, this wire having a good-sized ball at each end, so that the discharge may take the form of a spark or an explosion, and not pass off silently. Between the horizontal wire and the knob of the jar stretch a strip of gold-leaf ($B$), and charge the jar in the usual manner. So long as the electricity does not flow *through* the gold-leaf, the latter will remain uninjured, although it is evidently charged as intensely as the machine can charge it. But, if we discharge the jar by laying one ball of the discharger on the outer coat-

ing of the jar, and the other on the knob (*A*), the gold-leaf will be destroyed. If, for the strip of gold-leaf, a wire the one-thirtieth of an inch in diameter be substituted, the charge will be carried off without its doing any damage. Here we see that, while the electricity was at rest (*static*), the gold-leaf was quite capable of receiving as heavy a charge as the most powerful machine could impart; but, the moment the electricity began to flow (became *dynamic*), the gold-leaf was destroyed, notwithstanding its great surface, while a wire of far less surface afforded a perfect way for the charge to pass off.

Experiments in this direction might be multiplied *ad infinitum*, and, when properly conducted, they all lead to the same conclusion, which is, that, when made of the same metal, the efficiency of any rod is in direct proportion to its weight per foot. It may be round, square, tubular, ribbon-like, or in the form of a rope consisting of several strands; it makes no difference. For ourselves, we give the preference to a simple flat ribbon as being most easily applied and less obtrusive, but wires and wire ropes are very convenient, more easily procured, and quite as good.

That M. Nouel has neither experimented upon the subject nor given deep thought to it, is evident from the fact that he advises us to substitute hollow pipes for the present solid rods. As the interior surface of a pipe is incapable of receiving a charge of static electricity, it is evident that, if this law applies to lightning-conductors, the capacity of a pipe or tube would be just doubled by slitting it and spreading it out flat.

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# THE HIGHER EDUCATION.

By F. W. CLARKE,

PROFESSOR OF CHEMISTRY AND PHYSICS, UNIVERSITY OF CINCINNATI.

EDUCATORS, to-day, are divided into two schools, especially with regard to colleges and universities. The older of these schools insists very vigorously upon the importance of thorough instruction in the so-called "dead languages," and makes all else subordinate to them. The new school, on the other hand, the school which seems to be steadily gaining ground, upholds the claims of the sciences, and gives to them the places of honor in every general course of study. The controversy between these schools is well worn, but has not yet become threadbare. The questions at issue cannot grow stale and hackneyed until after they have been finally settled.

In discussing all such questions many commonplaces must be uttered. Indeed, much confusion has arisen among educational writers because they have too timidly feared to seem commonplace. These commonplaces are the necessary, rough foundations upon which

we must build; if we ignore or lose sight of them, our structure will be unsound. Simple facts must be stated in a simple way.

The first thing to be determined is, the true object of the higher education. Is it, as some would seem to suppose, purely ornamental, a thing valuable only as far as it gives a man extra polish and elegance of mind, a mere luxury, with no practical bearings upon the every-day duties of common, busy life? Such an idea is preposterous. Of course, ornamental culture is something to be desired; its acquirement confers honor upon the acquirer; facilities should be furnished for its attainment. But true education, including all this, goes far deeper. Its purpose is to develop the mind; to strengthen the thinking faculties in every possible direction; to render the acquisition of new knowledge easier and surer; to increase the student's resources; and to render him better fitted for dealing with the useful affairs of the world. Such an education is never completed; it grows throughout a lifetime; it is self-propagating; its most valuable features are acquired outside of schools and colleges. All that a college can do is to help lay its foundations, by training the mental power for subsequent use. Which course of studies best carries out this purpose?

The argument has been summed up by certain advocates of the new school in the following very condensed way: "Science deals with things, language with words. Words merely represent things. Surely the knowledge of the thing itself is worth more than the knowledge of its symbol." But this reasoning, however sound it may be at the core, is rather too curt and dogmatic to carry conviction. No reasonable being can deny the great value of a study of language. Different races of men must exchange their ideas. A man cannot be called liberally educated who has no knowledge of any tongue other than his own. But shall linguistic studies be allowed to occupy the first rank in our college courses? Are they to almost monopolize the attention of the student, or shall they be made subordinate to other things? Ought they to be taught independently for themselves alone, or should they be brought to bear upon other studies, so that all branches of learning may be made to fortify one another? The latter view, at least as far as our colleges are concerned, is unquestionably the correct one. The study of philology, or of language by itself, is undoubtedly of great value; but it is rather a study for the specialist than for the average student. It is, certainly, a true science; only, lacking precision in its methods, and being deficient in practical applicability to the general affairs of life, it must be left out of account for the present. In a general course of study a language should be taught because of its value in opening up other departments of knowledge. It should reveal to us the thoughts of other peoples, and enable us to avail ourselves of their experience. For most men these purposes are best fulfilled by a study of the modern tongues. Latin and Greek are valuable, no doubt, only they are less indispensable than French and Ger-

man. These newer languages are not only of practical value, being spoken and written by millions of our fellow-beings to-day, but they have also many direct bearings upon all modern life. The sciences cannot be well studied without them; they open up the widest fields of recent thought; they bring us into closer harmony with the spirit of our own times. We can get along better without a knowledge of antiquity than without a knowledge of the days in which we live. The history of the siege of Troy has less interest for us than the history of the great social and economic problems which are being worked out in such deadly earnest in our own country and in Europe to-day. The ancient languages have their uses, unquestionably; so also have the Russian and the Chinese; but are those uses of sufficient importance to warrant universal study? Remembering the aims of education, we must also remember that every student has but a limited number of years to spend at college. In those few years he must acquire that learning which will best fit him to go forth and grapple with active duties. If he has both the taste and the leisure, then he can learn the dead languages after graduation. It is nothing to urge that Latin and Greek facilitate the acquisition of French and German, since the latter can be studied directly as well as the former. Few people can afford the time to study four languages in order to use but two.

If we consider the languages in their bearings upon other studies, French and German again take the lead. For advanced study in philosophy or in science these tongues are absolutely necessary, while the dead languages are not. True, many scientific terms are derived from the Latin or the Greek; but the derivation is commonly lost in new technical meanings. Moreover, the derivation, if desired, can readily be learned and sufficiently understood without much knowledge of Latin grammar or much familiarity with Greek verbs. The philological facts may be valuable, but they are no more so than a host of other facts which must, for want of time, be omitted from every general course of study. As far as concerns the Latin, needed for the comprehension of nomenclature in the natural sciences, it is safe to say that any intelligent student can learn enough of the language in three months, if, indeed, he cares to study it regularly at all.

In the direction of literary pursuits, the modern languages, again, have the advantage. Undoubtedly, the literatures of the past are rich in grand poetry, in great thoughts, and in the history of noble deeds. But poetry as grand, thoughts as great, the history of deeds as noble, can be found in the literatures of to-day. Every thing of permanent value which the old contained has been translated into the new. Plato and Virgil may be read in English, French, or German; but Goethe, Racine, and Shakespeare, are not to be found in Greek. These modern literatures are certainly of as great value in any system of real culture as those of older times. No student can master all literatures, and therefore much must be rejected. First, a scholar should study

the classics of his own language, next in order taking others of his own time. When he knows something of his fellow-beings as he will meet them in the present, then he may learn with profit about the people of two thousand years ago. We profess to admire the culture of the Greeks. This culture came, not from the study of some language dead to them, but from direct intercourse with Nature and mankind. Cannot we draw new culture from the same sources?

As far, then, as concerns direct bearing upon practical life, the modern languages must take precedence of the ancient. And, if we look at education from a utilitarian stand-point, we cannot doubt that a knowledge of those sciences which are involved in the arts, whose principles are applied in the steam-engine and in the telegraph, is of more value to the average mind than an acquaintance with the languages of antiquity. Ornament is worth having, but for most people usefulness must rank first. But another question here comes up. It is plain that a modern education best fits a man to perform the external duties of life. But which education best develops the mind? Here we come in sight of the stronghold of the classicist. He claims for his system that it affords the best mental training. Is this true?

Let us see what has to be done. Looking at education solely as a means of intellectual development, we must inquire what faculties of the mind need to be cultivated. Three may be suggested at once: the reason, the memory, and the powers of observation. The æsthetic tastes should also be brought into play, and given good material for wholesome growth. In the treatment of each faculty, education, as its name indicates, should be a drawing out rather than a cramming in. It should give the student not only material, but power; not only train him to express his thoughts, but also furnish him with thoughts to express.

Beginning with the memory by itself, it is hard to see how either system of education can outrank the other. In the old school the memory is trained upon words and grammatical rules; in the new upon facts of observation and the laws deduced from them. But, if we consider the memory in connection with the other powers of the mind, we must give the modern education the highest place. Memory and the perceptive faculty are here cultivated side by side, as they cannot be in the mere study of language. Language does nothing for the observing powers. In science, on the other hand, the eye, the ear, and all the instruments of the senses, are trained to observe facts accurately, these facts are stored up in the memory, and the memory then renders it possible to exercise the reason upon them, generalize from them, and compare them with other facts gathered from other observers.

In the cultivation of the pure reason science again takes the lead. The element of judgment, which is exercised in the work of translating, is brought into play as much among modern languages as among

the ancient. It also finds its place in the classification of observed facts. Further than this, language offers the dry, arbitrary rules of grammar as food for the intellect, while science gives grand laws and generalizations already deduced or in process of deduction. The discovery of these natural laws may be counted among the greatest achievements of the human mind. To follow out the processes by which they were discovered, gives the mind its most rigid training, and elevates the tone of thought in many other respects. The intellect becomes self-reliant and yet conscious of its own weak points. On the other hand, grammatical reasoning binds one down to past authorities, and leaves no room for original thinking. It is purely conventional, nothing more. Originality, either of thought or of investigation, is discouraged by it. The mind may be filled, but not expanded. But surely the intellect ought to be trained to think forward as well as backward, in new regions as well as in the old, beaten paths. To the scientific student the universe appears full of great unsolved problems, whose solution is the noblest exercise for the human mind and a benefit to the race. To thoughts like these the mind of the mere grammarian is closed. He sees nothing but routine, and dreads all innovation. He fetters the intellect rather than loosens it.

It may be said, however, that the old education did not depend altogether upon the languages for intellectual training; that the mathematics were included, with a variety of philosophical and historical studies. True, but the new education also includes these branches, only in a better way. Their connection with modern times is much more intimate than their connection with antiquity. Modern languages aid in their cultivation to the highest degree. In philosophy, the modern has assimilated every thing of value from the ancient; and history, in the scientific sense, is just beginning to be written. As for mathematics, the old education made it a system of mental gymnastics; the new transforms it into a useful tool which the student must apply to the solution of many physical problems. Both the intellectual value and the utility of such studies have been vastly increased.

Turning toward æsthetic studies, we find the new education again foremost. Quite obviously, the æsthetic sense must be mainly cultivated through music, works of art and literature. The world's greatest music is all modern. So also are most of the famous works of art. The painter lives entirely among the achievements of recent or comparatively recent times. As for sculpture, one needs no Latin nor Greek in order to appreciate the Laocoon. Beauty is better understood by direct contact with beauty, than by reading about it in ancient books. And in literary studies the languages of to-day are more than on a par with those of the past. This part of the argument has already been mentioned.

In scientific pursuits, also, the æsthetic tastes find such nourish-

ment as they can get nowhere else. In a truly scientific education the art of drawing is an important element, and in the study of acoustics the musician wins great advantage. But we may look in other directions than these. No one can long handle a microscope without having his sense of the beautiful enlarged; nor can any one study modern astronomy without gaining the loftiest conceptions of the sublime. The true student of Nature and her phenomena ever sees order and symmetry coming out of chaos, and finds the rarest beauty hidden where to the unaided eye naught but ugliness exists. Must it not bring the highest satisfaction to the lover of beauty thus to find its traces everywhere? Can any student, who looks upon the universe with vision thus unobscured, fail to find in his studies the truest æsthetic culture?

Theoretically, then, we may conclude that the study of science, with modern languages, literatures, and philosophies as aids, does all for the mind that the old classical education ever did, and more. A higher discipline, a higher utility, and a higher culture, are its natural results. It trains memory, intellect, the perceptive faculties, and the sense of the beautiful simultaneously, insuring a symmetrical development. It brings men into closer relations with the spirit of modern civilization, bears directly upon all modern work, aids in practical after-life as no other education can, and helps the student to grow in all directions. This education not only fills the mind, but at the same time deepens and broadens it. In every definable respect it is superior to the old system. The latter was good enough in its day, but the new surpasses it in ours.

Yet it may be urged that all this is theory, and not borne out by facts. It is easy to point out college after college in this country in which, apparently, the classical and scientific courses have been tried side by side, to the evident disadvantage of the latter. Can this be explained?

Three things must here be taken into consideration: namely, the character of most American colleges, the character of many professed teachers, and the methods of study.

Beginning with the colleges and universities, it is noteworthy that there are to-day in our country about three hundred institutions bearing these names. Of these, Ohio has twenty-eight, while Pennsylvania, Illinois, and New York, have each twenty or over. For this deplorable scattering of educational forces, denominational rivalry is chiefly to blame. Where, by judicious management, one really efficient institution might be established, half a dozen sects, jealous of each other, build up as many insignificant weaklings. Each college acts as a drag on all the others. Libraries, cabinets, and faculties are uselessly duplicated. Naturally, one result of this state of affairs is a lowering of educational standards. It would be well for education if the several States would compel each so-called "university" to act up to its pretensions, become what it claims to be, or else forfeit its char-

ter. The educational frauds which many of these institutions perpetrate should no longer be tolerated. No new college ought to be chartered unless it has a proper endowment at the start. And, in a majority of our States, no new college should be chartered at all. Forces should be concentrated upon institutions already in existence.

But what has all this to do with the relative merits of the classics and science? Quite obviously, much. Since, on account of this foolish division of forces, most of these colleges are inadeqately endowed, they are compelled to work short-handed. One professor has frequently several branches to teach. Not long ago, in one of our Western colleges, a man was elected "professor of natural philosophy, astronomy, and the theory and practice of preaching!" In the majority of cases there is a chair of Latin, a chair of Greek, and then—a chair of "natural science!" Each linguistic professor is to some degree a specialist; while the one who teaches science is perforce compelled to be a smatterer. He is expected to teach half a dozen dissimilar branches, each one being a life-work by itself. He is to be omniscient on about $1,000 a year. Of course, in such a condition of things, the new education must suffer. No man living is able to teach properly more than one science. Indeed, some sciences, as, for example, chemistry, need to be subdivided into several different specialties, under several distinct teachers. Except by specialists, no truly scientific education can be given; since each instructor has to deal with a constantly-growing branch, and not with a fixed, completed study. The teacher must keep up with the growth of his particular science, or else drop into downright incompetency. He who is overworked by teaching several subjects cannot properly keep up with any one.

It is plain, then, that this scattering of educational forces is lowering to the character of the teacher, and that this effect is more evident and more mischievous in the wide realm of Science than in the comparatively narrow kingdom of the ancient languages. In still another way is the character of each college reflected in that of its professors. A Catholic institution will employ only Catholic instructors; a Methodist or Episcopalian university will seek out Methodists or Episcopalians; and so on. Instead of selecting teachers on the basis of capacity, the basis of belief is commonly chosen. The exceptions to this rule are rare, and are to be looked for chiefly in some of the older Eastern establishments, such as Yale, Bowdoin, Dartmouth, Union, and Columbia. This principle cannot fail to work mischief. A professor, and especially a professor of any science, should be elected because of his ability as a teacher, his knowledge, and his moral worth; not for his opinions upon some abstract theological dogma. A man may believe in sprinkling, and yet be competent to teach the chemistry of water even in a Baptist university.

One other consideration bearing upon the character of the teacher

remains to be noticed, and this will bring us naturally to the question of method. A large majority of our American college professors are graduates under the old *régime*. Having been trained in the old education, by the old methods, they are, consequently, unable to adapt themselves perfectly to the new. In the modern system, modern methods must be used. The old bottles will not hold the new wine. Formerly, instruction was given by lectures and text-book recitations; the student received, but gave nothing; he was placed upon a sort of Procrustean bedstead, and shaped according to a common pattern. The classics and mathematics were established things; the learner must take them as he found them; he was neither permitted to add nor to modify. Routine governed every thing. Differences of capacity, of tastes, and of needs, among a class of students went for nothing; there was so much raw material for the teacher to work up, and he must do it by the clumsiest rule and measure.

The new education is very different. Here we have a variety of subjects to be studied, each one best suited to a particular class of minds. The scholar who proves to be dull in one branch may be brilliant in another. Every branch is continually undergoing the changes attendant upon progress and growth. In each science new questions are continually arising; the higher we go up the mountain the wider our horizon will be. Through these changes the minds of both student and teacher are kept in constant activity; a condition requiring very different treatment from that given in the colleges of thirty years ago.

But the greatest changes in the educational method must be looked for in another direction. No longer are text-books and lectures adequate means of instruction; a new element must be brought in. This is the element of laboratory instruction. The student must not only hear about scientific truths, he must be able to demonstrate them in person. There are tools to be handled as well as books. If botany is to be studied, it must be partly in the field and partly with the microscope; if zoölogy, then the scalpel must be used; if chemistry or physics, the student must learn to perform his own experiments. Without practice of this sort the instruction will be largely thrown away. It is to science what the exercise of translation is to the study of language, or what the solution of problems is to mathematics. The student must be trained to observe for himself; then to generalize upon his observations. In no other manner can the natural and physical sciences be taught. All other teaching in them is a mere pretense. How many American colleges can boast a "scientific course" in which this method is *really* employed?

But this necessity again brings a disadvantage to science in very many institutions. A poorly-endowed college cannot afford suitable laboratories and apparatus, any more than it can afford to employ the specialists who are alone competent to manage them. Accordingly,

in four cases out of five, if not in a larger proportion, the sciences are improperly taught, by inferior or incompetent men, and therefore, as means of education, fall into disrepute. The classics have less rigorous needs, the proper teachers are more easily obtained, and thus they carry off a glory which is not rightfully theirs.

It is safe to say, in conclusion, that the new education will contrast unfavorably with the old only when it is imparted by incorrect methods or by improperly-trained teachers. The two systems, being so different, can hardly be compared upon the same ground. Let each do its own work, in its own way, with truly equal advantages, and, beyond a reasonable doubt, the new education will show the more vigor. Its greater utility, its wider range of discipline, and its more varied adaptability to dissimilar minds, unite to give it wonderful advantages.

# ON THE MOTIONS OF SOUND.

By JOHN TYNDALL, F. R. S.

## I.—ACOUSTIC REVERSIBILITY.

On the 21st and 22d of June, 1822, a commission appointed by the Bureau of Longitudes of France executed a celebrated series of experiments on the velocity of sound. Two stations had been chosen, the one at Villejuif, the other at Montlhéry, both lying south of Paris, and 11.6 miles distant from each other. Prony, Mathieu, and Arago, were the observers at Villejuif, while Humboldt, Bouvard, and Gay-Lussac, were at Montlhéry. Guns, charged sometimes with three pounds of powder, were fired at both stations, and the velocity was deduced from the interval between the appearance of the flash and the arrival of the sound.

On this memorable occasion an observation was made which, as far as I know, has remained a scientific enigma to the present hour. It was noticed that while every report of the cannon fired at Montlhéry was heard with the greatest distinctness at Villejuif, by far the greater number of the reports from Villejuif failed to reach Montlhéry. Had wind existed, and had it blown from Montlhéry to Villejuif, it would have been recognized as the cause of the observed difference; but the air at the time was calm, the slight motion of translation actually existing being from Villejuif toward Montlhéry, or against the direction in which the sound was best heard.

So marked was the difference in transmissive power between the two directions that on the 22d of June while every shot fired at Montlhéry was heard *à merveille* [with wonderful distinctness] at Villejuif, but one shot out of twelve fired at Villejuif was heard, and that feebly, at the other station.

With the caution which characterized him on other occasions, and which has been referred to admiringly by Faraday,[1] Arago made no attempt to explain this anomaly. His words are: "As for the very notable differences of intensity constantly observed in the sound of the cannon accordingly as it was propagated from north to south between Villejuif and Montlhéry, or from south to north between the latter station and the former, we will not at present try to explain it, as we could present to the reader only conjectures unsupported by evidence."[2]

I have tried, after much perplexity of thought, to bring this subject within the range of experiment, and have now to submit to the Royal Society a possible solution of this enigma. The first step was to ascertain whether the sensitive flame referred to in my recent paper in the "Philosophical Transactions" could be safely employed in experiments on the mutual reversibility of a source of sound and an object on which the sound impinges. Now, the sensitive flame usually employed by me measures from eighteen to twenty-four inches in height, while the reed employed as a source of sound is less than a square quarter of an inch in area. If, therefore, the whole flame or the pipe which fed it were sensitive to sonorous vibrations, strict experiments on reversibility with the reed and flame might be difficult, if not impossible. Hence my desire to learn whether the seat of sensitiveness was so localized in the flame as to render the contemplated interchange of flame and reed permissible.

The flame being placed behind a cardboard screen, the shank of a funnel, passed through a hole in the cardboard, was directed upon the middle of the flame. The sound-waves issuing from the vibrating reed placed within the funnel produced no sensible effect upon the flame. Shifting the funnel so as to direct its shank upon the root of the flame, the action was violent.

To augment the precision of the experiment, the funnel was connected with a glass tube three feet long and half an inch in diameter, the object being to weaken by distance the effect of the waves diffracted round the edge of the funnel, and to permit those only which passed through the glass tube to act upon the flame.

Presenting the end of the tube to the orifice of the burner (*b*, Fig. 1), or the orifice to the end of the tube, the flame was violently agitated by the sounding-reed, *R*. On shifting the tube, or the burner, so as to concentrate the sound on a portion of the flame about half an inch above the orifice, the action was *nil*. Concentrating the sound upon the burner itself about half an inch below its orifice, there was no action.

These experiments demonstrate the localization of "the seat of

[1] "Researches in Chemistry and Physics," p. 484.

[2] Tyndall gives the passage in French, as found in the "Connaissance des Temps," 1825, p. 370.—Ed.

sensitiveness," and they prove the flame to be an appropriate instrument for the contemplated experiments on reversibility.

The experiments proceeded thus: The sensitive flame being placed close behind a screen of cardboard eighteen inches high by twelve inches wide, a vibrating reed, standing at the same height as the root of the flame, was placed at a distance of six feet on the other side of the screen. The sound of the reed, in this position, produced a strong agitation of the flame.

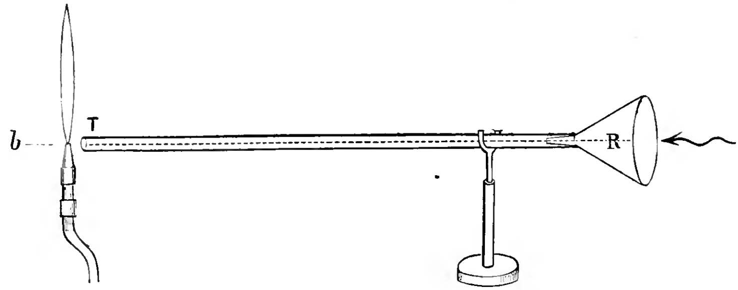



FIG. 1.

The whole upper half of the flame was here visible from the reed; hence the necessity of the foregoing experiments to prove the action of the sound on the upper portion of the flame to be *nil*, and that the waves had really to bend round the edge of the screen so as to reach the seat of sensitiveness in the neighborhood of the burner.

The positions of the flame and reed were reversed, the latter being now close behind the screen, and the former at a distance of six feet from it. The sonorous vibrations were without sensible action upon the flame.

The experiment was repeated and varied in many ways. Screens of various sizes were employed, and, instead of reversing the positions of the flame and reed, the screen was moved so as to bring, in some experiments the flame, and in other experiments the reed, close behind it. Care was also taken that no reflected sound from the walls or ceiling of the laboratory, or from the body of the experimenter, should have any thing to do with the effect. In all cases it was shown that the sound was effective when the reed was at a distance from the screen, and the flame close behind it; while the action was insensible when the positions were reversed.

Thus let *s e*, Fig. 2, be a vertical section of the screen. When the reed was at *A*, and the flame at *B*, there was no action; when the reed was at *B*, and the flame at *A*, the action was decided. It may be added that the vibrations communicated to the screen itself, and from it to the air beyond it, were without effect; for when the reed, which at *B* is effectual, was shifted to *C*, where its action on the screen was greatly augmented, it ceased to have any action on the flame at *A*.

We are now, I think, prepared to consider the failure of reversibility in the larger experiments of 1822. Happily an incidental observation of great significance comes here to our aid. It was observed and recorded at the time that while the reports of the guns at Villejuif were without echoes, a roll of echoes, lasting from twenty to twenty-five seconds, accompanied every shot at Montlhéry, being heard by the observers there. Arago, the writer of the report, referred these echoes to reflection from the clouds, an explanation which I think we are entitled to regard as problematical. The report says that "all the shots fired at Montlhéry were there *accompanied*


FIG. 2.

by a rolling sound like that of thunder."[1] I have italicized a very significant word—a word which fairly applies to our experiments on gun-sounds at the South Foreland, where there was no sensible solution of continuity between explosion and echo, but which could hardly apply to echoes coming from the clouds. For, supposing the clouds to be only a mile distant, the sound and its echo would have been separated by an interval of nearly ten seconds. But there is no mention of any interval; and, had such existed, surely the word "followed," instead of "accompanied," would have been the one employed. The echoes, moreover, appear to have been *continuous*, while the clouds observed seem to have been *separate*. "These phenomena," says Arago, "never took place except at the moment when some clouds appeared."[2] But from separate clouds a continuous roll of echoes could hardly come. When to this is added the experimental fact that clouds far denser than any ever formed in the atmosphere are demonstrably incapable of sensibly reflecting sound, while cloudless air, which Arago pronounced echoless, has been proved capable of powerfully reflecting it, I think we have strong reason to question the hypothesis of the illustrious French philosopher.

And considering the hundreds of shots fired at the South Foreland, with the attention specially directed to the aërial echoes, when no single case occurred in which echoes of measurable duration did not accompany the report of the gun, I think Arago's statement, that at Villejuif no echoes were heard when the sky was clear, must simply mean that they vanished with great rapidity. Unless the attention

[1] Tyndall quotes the French.—ED. [2] The French quoted by Tyndall.—ED.

were specially directed to the point, a slight prolongation of the cannon-sound might well escape observation; and it would be all the more likely to do so if the echoes were so loud and prompt as to form apparently part and parcel of the direct sound.

I should be very loath to transgress here the limits of fair criticism, or to throw doubt, without good reason, on the recorded observations of an eminent man; still, taking into account what has just been stated, and remembering that the minds of Arago and his colleagues were occupied by a totally different problem (that the echoes were an incident rather than an object of observation), I think we may justly consider the sound which he called "instantaneous" as one whose aërial echoes did not differentiate themselves from the direct sound by any noticeable fall of intensity, and which rapidly died into silence.

Turning now to the observations at Montlhéry, we are struck by the extraordinary duration of the echoes heard at that station. At the South Foreland the charge habitually fired was equal to the largest of those employed by the French philosophers; but on no occasion did the gun-sounds produce echoes approaching to twenty or twenty-five seconds duration. It rarely reached half this amount. Even the siren-echoes, which were far more remarkable, more long-continued than those of the guns, never reached the duration of the Montlhéry echoes. The nearest approach to it was on the 17th of October, 1873, when the siren-echoes required fifteen seconds to subside into silence.

On this same day, moreover (and this is a point of marked significance), the transmitted sound reached its maximum range, the gun-sounds being heard at the Quenocs buoy, which is 16½ nautical miles from the South Foreland. I have already stated that the duration of the air-echoes indicates "the atmospheric depths" from which they come.[1] An optical analogy may help us here. Let light fall upon chalk, the light is wholly scattered by the superficial particles; let the chalk be powdered and mixed with water, light reaches the observer from a far greater depth of the turbid liquid. The chalk typifies the action of exceedingly dense acoustic clouds; the chalk and water that of clouds of moderate density. In the one case we have echoes of short, in the other, echoes of long duration. These considerations prepare us for the inference that Montlhéry, on the occasion referred to, must have been surrounded by a highly-diacoustic atmosphere; while the shortness of the echoes at Villejuif shows the atmosphere surrounding that station to have been acoustically opaque.

Have we any clew to the cause of the opacity? I think we have. Villejuif is close to Paris, and over it, with the observed light wind, was slowly wafted the air from the city. Thousands of chimneys to windward of Villejuif were discharging their heated currents, so that an atmosphere non-homogeneous in a high degree must have surrounded that station. At no great height in the atmosphere the equi-

[1] "Philosophical Transactions," 1874, Part I., p. 202.

librium of temperature would be established. The non-homogeneous air surrounding Villejuif is experimentally typified by our screen with the source of sound close behind it, the upper edge of the screen representing the place where equilibrium of temperature was established in the atmosphere above the station. In virtue of its proximity to the screen, the echoes from our sounding-reed would, in the case here supposed, so blend with the direct sound as to be practically indistinguishable from it, as the echoes at Villejuif followed the direct sound so hotly, and vanished so rapidly, that they escaped observation. And as our sensitive flame, at a distance, failed to be affected by the sounding body placed close behind the cardboard screen, so, I take it, did the observer at Montlhéry fail to hear the sounds of the Villejuif gun.

Something further may be done toward the experimental elucidation of this subject. The facility with which sounds pass through textile fabrics has been already illustrated,[1] a layer of cambric or calico, or even of thick flannel or baize being found competent to intercept but a fraction of the sound from a vibrating reed. Such a layer of calico may be taken to represent a layer of air differentiated from its neighbors by temperature or moisture; while a succession of such sheets of calico may be taken to represent successive layers of non-homogeneous air.

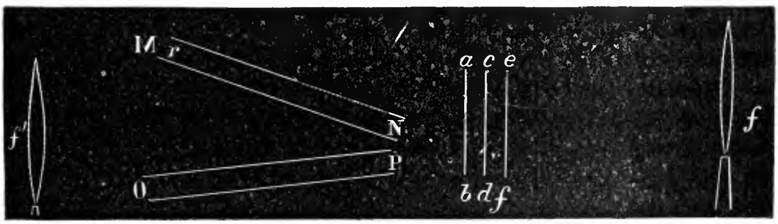



Fig. 3.

Two tin tubes ($M\ N$ and $O\ P$, Fig. 3) with open ends are placed so as to form an acute angle with each other. At the end of one is the vibrating reed $r$, opposite the end of the other and in the prolongation of $P\ O$ is the sensitive flame $f$, a second sensitive flame ($f'$) being placed in the continuation of the axis of $M\ N$. On sounding the reed, the direct sound through $M\ N$ agitates the flame $f'$. Introducing the square of calico $a\ b$ at the proper angle, a slight decrease of the action on $f'$ is noticed, and the feeble echo from $a\ b$ produces a barely perceptible agitation of the flame $f$. Adding another square, $c\ d$, the sound transmitted by $a\ b$ impinges on $c\ d$; it is partially echoed, returns through $a\ b$, passes along $P\ O$, and still further agitates the flame $f$. Adding a third square, $e\ f$, the reflected sound is still further augmented, every accession to the echo being accompanied by a corre-

[1] "Philosophical Transactions," 1874, Part 1., p. 208.

sponding withdrawal of the vibrations from $f'$, and a consequent stilling of that flame.

With thinner calico or cambric it would require a greater number of layers to intercept the entire sound; hence, with such cambric we should have echoes returned from a greater distance, and therefore of greater duration. Eight layers of the calico employed in these experiments, stretched on a wire frame, and placed close together as a kind of pad, may be taken to represent a very dense acoustic cloud. Such a pad, placed at the proper angle beyond it, cuts off the sound which in its absence reaches $f'$, almost as effectually as an impervious solid plate; the flame $f'$ is thereby stilled, while $f$ is far more powerfully agitated than by the reflection from a single layer. With the source of sound close at hand, the echoes from such a pad would be of insensible duration. Thus close at hand do I suppose the acoustic clouds surrounding Villejuif to have been, a similar shortness of echo being the consequence.

A further step is here taken in the illustration of the analogy between light and sound. Our pad acts chiefly by internal reflection. The sound from the reed is a composite one, made up of partial sounds, differing in pitch. If these sounds be ejected from the pad in their pristine proportions, the pad is acoustically *white;* if they return with their proportions altered, the pad is acoustically *colored.*

In these experiments my assistant, Mr. Cottrell, has rendered me material assistance.

### II.—STATE OF THE RESEARCH.[1]

In preparing this new edition of "Sound," I have carefully gone over the last one, amended, as far as possible, its defects of style and matter, and paid at the same time respectful attention to the criticisms and suggestions which the former editions called forth.

The cases are few in which I have been content to reproduce what I have *read* of the works of acousticians. I have sought to make myself experimentally familiar with the ground occupied; trying, in all cases, to present the illustrations in the form and connection most suitable for educational purposes.

Though bearing, it may be, an undue share of the imperfection which cleaves to all human effort, the work has already found its way into the literature of various nations of diverse intellectual standing. Last year, for example, a new German edition was published "under the special supervision" of Helmholtz and Wiedemann. That men so eminent, and so overladen with official duties, should add to these the labor of examining and correcting every proof-sheet of a work like this, shows that they consider it to be what it was meant to be—a serious attempt to improve the public knowledge of science. It is especially gratifying to me to be thus assured that not in England

[1] Preface to forthcoming third edition of "Sound." By John Tyndall, F. R. S.

alone has the book met a public want, but also in that learned land to which I owe my scientific education.

Before me, on the other hand, lie two volumes, of foolscap size, curiously stitched, and printed in characters the meaning of which I am incompetent to penetrate. Here and there, however, I notice the familiar figures of the former editions of "Sound." For these volumes I am indebted to Mr. John Fryer, of Shanghai, who, along with them, favored me, a few weeks ago, with a letter, from which the following is an extract: "One day," writes Mr. Fryer, "soon after the first copy of your work on 'Sound' reached Shanghai, I was reading it in my study, when an intelligent official, named Hsii-chung-hu, noticed some of the engravings, and asked me to explain them to him. He became so deeply interested in the subject of Acoustics, that nothing would satisfy him but to make a translation. Since, however, engineering and other works were then considered to be of more practical importance by the higher authorities, we agreed to translate your work during our leisure time every evening, and publish it separately ourselves. Our translation, however, when completed, and shown to the higher officials, so much interested them and pleased them, that they at once ordered it to be published at the expense of the Government, and sold at cost price. The price is four hundred and eighty copper cash per copy, or about one shilling and eightpence. This will give you an idea of the cheapness of native printing." Mr. Fryer adds that his Chinese friend had no difficulty in grasping every idea in the book.

The new matter of greatest importance which has been introduced into this edition is an account of an investigation which, during the two past years, I have had the honor of conducting in connection with the Elder Brethren of the Trinity House. Under the title "Researches on the Acoustic Transparency of the Atmosphere, in relation to the Question of Fog-signaling," the subject is treated in Chapter VII. of this volume. It was only by governmental appliances that such an investigation could have been made; and it gives me pleasure to believe that not only have the practical objects of the inquiry been secured, but that a crowd of scientific errors, which for more than a century and a half have surrounded this subject, have been removed, their place being now taken by the sure and certain truth of Nature. In drawing up the account of this laborious inquiry, I aimed at linking the observations so together, that they alone should offer a substantial demonstration of the principles involved. Further labors enabled me to bring the whole inquiry within the firm grasp of *experiment*, and thus to give it a certainty which, without this final guarantee, it could scarcely have enjoyed.

Immediately after the publication of the first brief abstract of the investigation, it was subjected to criticism. To this I did not deem

it necessary to reply, believing that the grounds of it would disappear in presence of the full account. The only opinion to which I thought it right to defer was to some extent a private one, communicated to me by Prof. Stokes. He considered that I had, in some cases, ascribed too exclusive an influence to the mixed currents of aqueous vapor and air, to the neglect of differences of temperature. That differences of temperature, when they come into play, are an efficient cause of acoustic opacity, I never doubted. In fact, aërial reflection arising from this cause is, in the present inquiry, for the first time made the subject of experimental demonstration. What the relative potency of differences of temperature and differences due to aqueous vapor, in the cases under consideration, may be, I do not venture to state; but, as both are active, I have, in Chapter VII., referred to them jointly as concerned in the production of those "acoustic clouds" to which the stoppage of sound in the atmosphere is for the most part due.

Subsequently, however, to the publication of the full investigation, another criticism appeared, to which, in consideration of its source, I would willingly pay all respect and attention. In this criticism, which reached me first through the columns of an American newspaper, differences in the amounts of aqueous vapor, and differences of temperature, are alike denied efficiency as causes of acoustic opacity. At a meeting of the Philosophical Society of Washington, the emphatic opinion had, it was stated, been expressed that I was wrong in ascribing the opacity of the atmosphere to its flocculence, the really efficient cause being *refraction*. This view appeared to me so obviously mistaken that I assumed, for a time, the incorrectness of the newspaper account.

Recently, however, I have been favored with the "Report of the United States Lighthouse Board for 1874," in which the account just referred to is corroborated. A brief reference to this report will here suffice. Major Elliott, the accomplished officer and gentleman referred to at page 261, had published a record of his visit of inspection to this country, in which he spoke, with a perfectly enlightened appreciation of the facts, of the differences between our system of lighthouse illumination and that of the United States. He also embodied in his report some account of the investigation on fog-signals, the initiation of which he had witnessed, and indeed aided, at the South Foreland.

On this able report of their own officer the Lighthouse Board at Washington make the following remark: "Although this account is interesting in itself and to the public generally, yet, being addressed to the Lighthouse Board of the United States, it would tend to convey the idea that the facts which it states were new to the Board, and that the latter had obtained no results of a similar kind; while a reference to the Appendix to this Report[1] will show that the researches of our

[1] It will be borne in mind that the Washington Appendix was published nearly a year after my Report to the Trinity House.

Lighthouse Board have been much more extensive on this subject than those of the Trinity House, and that the latter has established no facts of practical importance which had not been previously observed and used by the former."

The "Appendix" here referred to is from the pen of the venerable Prof. Joseph Henry, chairman of the Lighthouse Board at Washington. To his credit be it recorded that, at a very early period in the history of fog-signaling, Prof. Henry reported in favor of Daboll's trumpet, though he was opposed by one of his colleagues on the ground that "fog-signals were of little importance, since the mariner should know his place by the character of his soundings." In the Appendix, he records the various efforts made in the United States with a view to the establishment of fog-signals. He describes experiments on bells, and on the employment of reflectors to reënforce their sound. These, though effectual close at hand, were found to be of no use at a distance. He corrects current errors regarding steam-whistles, which by some inventors were thought to act like ringing bells. He cites the opinion of the Rev. Peter Ferguson, that sound is better heard in fog than in clear air. This opinion is founded on observations of the noise of locomotives; in reference to which it may be said that others have drawn from similar experiments diametrically opposite conclusions. On the authority of Captain Keeney he cites an occurrence, "in the first part of which the captain was led to suppose that fog had a marked influence in deadening sound, though in a subsequent part he came to an opposite conclusion." Prof. Henry also describes an experiment made during a fog at Washington, in which he employed "a small bell rung by clock-work, the apparatus being the part of a moderator lamp intended to give warning to the keepers when the supply of oil ceased. The result of the experiment was, he affirms, contrary to the supposition of absorption of the sound by the fog." This conclusion is not founded on comparative experiments, but on observations made in the fog alone; "for," adds Prof. Henry, "the change in the condition of the atmosphere, as to temperature and the motion of the air, before the experiment could be repeated in clear weather, rendered the result not entirely satisfactory."

This, I may say, is the only experiment on fog which I have found recorded in the Appendix.

In 1867 the steam-siren was mounted at Sandy Hook, and examined by Prof. Henry. He compared its action with that of a Daboll trumpet, employing for this purpose a stretched membrane covered with sand, and placed at the small end of a tapering tube which concentrated the sonorous motion upon the membrane. The siren proved most powerful. "At a distance of 50, the trumpet produced a decided motion of the sand, while the siren gave a similar result at a distance of 58." Prof. Henry also varied the pitch of the siren, and found that, in association with its trumpet, 400 impulses per second yielded the

maximum sound; while the best result with the unaided siren was obtained when the impulses were 360 a second. Experiments were also made on the influence of pressure; from which it appeared that, when the pressure varied from 100 lbs. to 20 lbs., the distance reached by the sound (as determined by the vibrating membrane) varied only in the ratio of 61 to 51. Prof. Henry also showed the sound of the fog-trumpet to be independent of the material employed in its construction; and he furthermore observed the decay of the sound when the angular distance from the axis of the instrument was increased. Further observations were made by Prof. Henry and his colleagues in August, 1873, and in August and September, 1874. In the brief but interesting account of these experiments an hypothetical element appears, which is absent from the record of the earlier observations.

It is quite evident from the foregoing that, in regard to the question of fog-signaling, the Lighthouse Board of Washington have not been idle. Add to this the fact that their eminent chairman gives his services gratuitously, conducting without fee or reward experiments and observations of the character here revealed, and I think it will be conceded that he not only deserves well of his own country, but also sets his younger scientific contemporaries, both in his country and ours, an example of high-minded devotion.

I was quite aware, in a general way, that labors like those now for the first time made public had been conducted in the United States, and this knowledge was not without influence upon my conduct. The first instruments mounted at the South Foreland were of English manufacture; and I, on various accounts, entertained a strong sympathy for their able constructor, Mr. Holmes. From the outset, however, I resolved to suppress such feelings, as well as all other extraneous considerations, individual or national, and to aim at obtaining the best instruments, irrespective of the country which produced them. In reporting, accordingly, on the observations of May 19 and 20, 1873 (our first two days at the South Foreland), these were my words to the Elder Brethren of the Trinity House:

"In view of the reported performance of horns and whistles in other places, the question arises whether those mounted at the South Foreland, and to which the foregoing remarks refer, are of the best possible description. . . . I think our first duty is to make ourselves acquainted with the best instruments hitherto made, no matter where made; and then, if home genius can transcend them, to give it all encouragement. Great and unnecessary expense may be incurred, through our not availing ourselves of the results of existing experience.

"I have always sympathized, and I shall always sympathize, with the desire of the Elder Brethren to encourage the inventor who first made the magneto-electric light available for lighthouse purposes. I regard his aid and counsel as, in many respects, invaluable to the corporation. But however original he may be, our duty is to demand that his genius shall be expended in making advances on that which has been already achieved elsewhere. If the whistles and horns that we heard on the 19th and 20th be the very best hitherto constructed, my

views have been already complied with; but if they be not—and I am strongly inclined to think that they are not—then I would submit that it behooves us to have the best, and to aim at making the South Foreland, both as regards light and sound, a station not excelled by any other in the world."

On this score it gives me pleasure to say that I never had a difficulty with the Elder Brethren. They agreed with me; and two powerful steam-whistles, the one from Canada, the other from the United States, together with the steam-siren—also an American instrument—were in due time mounted at the South Foreland. It will be seen, in Chapter VII., that my strongest recommendation applies to an instrument for which we are indebted to the United States.

In presence of these facts, it will hardly be assumed that I wish to withhold from the Lighthouse Board of Washington any credit that they may fairly claim. My desire is to be strictly just; and this desire compels me to express the opinion that their report fails to establish the inordinate claim made in its first paragraph. It contains observations, but contradictory observations; while, as regards the establishment of any principle which should reconcile the conflicting results, it leaves our condition unimproved.

But I willingly turn aside from the discussion of "claims" to the discussion of science. Inserted, as a kind of intrusive element, into the Report of Prof. Henry, is a second Report by General Duane, founded on an extensive series of observations made by him in 1870 and 1871. After stating with distinctness the points requiring decision, the general makes the following remarks:

"Before giving the results of these experiments, some facts will be stated which will explain the difficulties of determining the power of a fog-signal.

"There are six steam fog-whistles on the coast of Maine: these have been frequently heard at a distance of twenty miles, and as frequently cannot be heard at the distance of two miles, and this with no perceptible difference in the state of the atmosphere.

"The signal is often heard at a great distance in one direction, while in another it will be scarcely audible at the distance of a mile. This is not the effect of wind, as the signal is frequently heard much farther against the wind than with it.[1] For example, the whistle on Cape Elizabeth can always be distinctly heard in Portland, a distance of nine miles, during a heavy northeast snowstorm, the wind blowing a gale directly from Portland toward the whistle.[2]

"The most perplexing difficulties, however, arise from the fact that the signal often appears to be surrounded by a belt, varying in radius from one to one and a half mile, from which the sound appears to be entirely absent. Thus, in moving directly from a station the sound is audible for the distance of a mile, is then lost for about the same distance, after which it is again distinctly heard for

[1] That is to say, homogeneous air with an opposing wind is frequently more favorable to sound than non-homogeneous air with a favoring wind. We made the same experience at the South Foreland.—J. T.

[2] Had this observation been published, it could only have given me pleasure to refer to it in my recent writings. It is a striking confirmation of my observations on the Mer de Glace in 1859.

a long time. This action is common to all ear-signals, and has been at times observed at all the stations, at one of which the signal is situated on a bare rock twenty miles from the main-land, with no surrounding objects to affect the sound."

It is not necessary to assume here the existence of a "belt," at some distance from the station. The passage of an acoustic cloud over the station itself would produce the observed phenomenon.

Passing over the record of many other valuable observations, in the Report of General Duane, I come to a few very important remarks which have a direct bearing upon the present question:

"From an attentive observation," writes the general, "during three years, of the fog-signals on this coast, and from the reports received from the captains and pilots of coasting-vessels, I am convinced that, in some conditions of the atmosphere, the most powerful signals will be at times unreliable.[1]

"Now it frequently occurs that a signal, which under ordinary circumstances would be audible at a distance of fifteen miles, cannot be heard from a vessel at the distance of a single mile. This is probably due to the reflexion mentioned by Humboldt.

"The temperature of the air over the land where the fog-signal is located being very different from that over the sea, the sound, in passing from the former to the latter, undergoes reflexion at their surface of contact. The correctness of this view is rendered more probable by the fact that, when the sound is thus impeded in the direction of the sea, it has been observed to be much stronger inland.

"Experiments and observation lead to the conclusion that these anomalies in the penetration and direction of sound from fog-signals are to be attributed mainly to the want of uniformity in the surrounding atmosphere, and that snow, rain, and fog, and the direction of the wind, have much less influence than has been generally supposed."

The Report of General Duane is marked throughout by fidelity to facts, rare sagacity, and soberness of speculation. The last three of the paragraphs just quoted exhibit, in my opinion, the only approach to a true explanation of the phenomena which the Washington Report reveals. At this point, however, the eminent chairman of the Lighthouse Board strikes in with the following criticism:

"In the foregoing I differ entirely in opinion from General Duane, as to the cause of extinction of powerful sounds being due to the unequal density of the atmosphere. The velocity of sound is not at all affected by barometric pressure; but if the difference in pressure is caused by a difference in heat, or by the expansive power of vapor mingled with the air, a slight degree of obstruction of sound may be observed. But this effect we think is entirely too minute to produce the results noted by General Duane and Dr. Tyndall, while we shall find in the action of currents above and below a true and efficient cause."

I have already cited the remarkable observation of General Duane, that, with a snow-storm from the northeast blowing against the sound,

[1] Had I been aware of its existence I might have used the language of General Duane to express my views on the point here adverted to. (*See* chapter vii., pp. 319, 320.)

the signal at Port Elizabeth is always heard at Portland, a distance of nine miles. The observations at the South Foreland, where the sound has been proved to reach a distance of more than twelve miles against the wind, backed by decisive experiments, reduce to certainty the surmises of General Duane. It has, for example, been proved that a couple of gas-flames placed in a chamber can, in a minute or two, render its air so non-homogeneous as to cut a sound practically off; while the same sound passes without sensible impediment through showers of paper-scraps, seeds, bran, rain-drops, and through fumes and fogs of the densest description. The sound also passes through thick layers of calico, silk, serge, flannel, baize, close felt, and through pads of cotton-net impervious to the strongest light.

As long indeed as the air on which snow, hail, rain, or fog, is suspended is homogeneous, so long will sound pass through the air, sensibly heedless of the suspended matter.[1] This point is illustrated upon a large scale by my own observations on the Mer de Glace, and by those of General Duane, at Portland, which prove the snow-laden air from the northeast to be a highly homogeneous medium. Prof. Henry thus accounts for the fact that the northeast snow-wind renders the sound of Cape Elizabeth audible at Portland: In the higher regions of the atmosphere he places an ideal wind, blowing in a direction opposed to the real one, which *always* accompanies the latter, and which more than neutralizes its action. In speculating thus he bases himself on the reasoning of Prof. Stokes, according to which a sound-wave moving against the wind is tilted upward. The upper and opposing wind is invented for the purpose of tilting again the already lifted sound-wave downward. Prof. Henry does not explain how the sound-wave recrosses the hostile lower current, nor does he give any definite notion of the conditions under which it can be shown that it will reach the observer.

This, so far as I know, is the only theoretic gleam cast by the Washington Report on the conflicting results which have hitherto rendered experiments on fog-signals so bewildering. I fear it is an *ignis fatuus*, instead of a safe guiding light. Prof. Henry, however, boldly applies the hypothesis in a variety of instances. But he dwells with particular emphasis upon a case of non-reciprocity which he considers absolutely fatal to my views regarding the flocculence of the atmosphere. The observation was made on board the steamer City of Richmond, during a thick fog in a night of 1872. "The vessel was approaching Whitehead from the southwestward, when, at a distance of about six miles from the station, the fog-signal, which is a ten-inch steam-whistle, was distinctly perceived, and continued to be heard with increasing intensity of sound until within about three miles, when the sound suddenly ceased to be heard, and was not perceived again until the vessel approached within a quarter of a mile of the sta-

[1] This is not more surprising than the passage of radiant heat through rock-salt.

tion, although from conclusive evidence, furnished by the keeper, it was shown that the signal had been sounding during the whole time."

But, while the ten-inch shore-signal thus failed to make itself heard at sea, a six-inch whistle, on board the steamer, made itself heard on shore. Prof. Henry thus turns this fact against me: "It is evident," he writes, "that this result could not be due to any mottled condition or want of acoustic transparency in the atmosphere, since this would absorb the sound equally in both directions." Had the observation been made in a still atmosphere, this argument would, at one time, have had great force. But the atmosphere was not still, and a sufficient reason for the observed non-reciprocity is to be found in the recorded fact that the wind was blowing against the shore-signal, and in favor of the ship-signal.

But the argument of Prof. Henry, on which he places his main reliance, would be untenable, even had the air been still. By the very aërial reflexion which he practically ignores, reciprocity may be destroyed in a calm atmosphere. In proof of this assertion I would refer him to a short paper on "Acoustic Reversibility," printed at the end of this volume.[1] The most remarkable case of non-reciprocity on record, and which, prior to the demonstration of the existence and power of acoustic clouds, remained an insoluble enigma, is there shown to be capable of satisfactory solution. These clouds explain perfectly the "abnormal phenomena" of Prof. Henry. Aware of their existence, the falling off and subsequent recovery of a signal-sound, as noticed by him and General Duane, is no more a mystery than the interception of the solar light by a common cloud, and its restoration after the cloud has moved or melted away.

The clew to all the difficulties and anomalies of this question is to be found in the aërial echoes, the significance of which has been overlooked by General Duane, and misinterpreted by Prof. Henry. And here a word might be said with regard to the injurious influence still exercised by authority in science. The affirmations of the highest authorities, that from clear air no sensible echo ever comes, were so distinct, that my mind for a time refused to entertain the idea. Authority caused me for weeks to depart from the truth, and to seek counsel among delusions. On the day our observations at the South Foreland began, I heard the echoes. They perplexed me. I heard them again and again, and listened to the explanations offered by some ingenious persons at the Foreland. They were an "ocean-echo:" this is the very phraseology now used by Prof. Henry. They were echoes "from the crests and slopes of the waves:" these are the words of the hypothesis which he now espouses. Through a portion of the month of May, through the whole of June, and through nearly the whole of July, 1873, I was occupied with these echoes; one of

[1] Also "Proceedings of Royal Society," vol. xxiii., p. 159, and "Proceedings of Royal Institute," vol. vii., p. 344.

the phases of thought then passed through, one of the solutions then weighed in the balance and found wanting, being identical with that which Prof. Henry now offers for acceptation.

But though it thus deflected me from the proper track, shall I say that authority in science is injurious? Not without some qualification. It is not only injurious, but deadly, when it cows the intellect into fear of questioning it. But the authority which so merits our respect as to compel us to test and overthrow all its supports, before accepting a conclusion opposed to it, is not wholly noxious. On the contrary, the disciplines it imposes may be in the highest degree salutary, though they may end, as in the present case, in the ruin of authority. The truth thus established is rendered firmer by our struggles to reach it. I groped day after day, carrying this problem of aërial echoes in my mind; to the weariness, I fear, of some of my colleagues who did not know my object. The ships and boats afloat, the "slopes and crests of the waves," the visible clouds, the cliffs, the adjacent lighthouses, the objects landward, were all in turn taken into account, and all in turn rejected.

With regard to the particular notion which now finds favor with Prof. Henry, it suggests the thought that his observations, notwithstanding their apparent variety and extent, were really limited as regards the weather. For did they, like ours, embrace weather of all kinds, it is not likely that he would have ascribed to the sea-waves an action which often reaches its maximum intensity when waves are entirely absent. I will not multiply instances, but confine myself to the definite statement, that the echoes have often manifested an astonishing strength, when the sea was of glassy smoothness. On days when the echoes were powerful, I have seen the southern cumuli mirrored in the waveless ocean, in forms almost as definite as the clouds themselves. By no possible application of the law of incidence and reflexion could the echoes from such a sea return to the shore; and, if we accept, for a moment, a statement which Prof. Henry seems to indorse, that sound-waves of great intensity, when they impinge upon a solid or liquid surface, do not obey the law of incidence and reflexion, but "roll along the surface like a cloud of smoke," it only increases the difficulty. Such a "cloud," instead of returning to the coast of England, would, in our case, have rolled toward the coast of France. Nothing that I could say in addition could strengthen the case here presented. I will only add one further remark. When the sun shines uniformly, on a smooth sea, thus producing a practically uniform distribution of the aërial currents to which the echoes are due, the direction in which the trumpet-echoes reach the shore is always that in which the axis of the instrument is pointed. At Dungeness this was proved to be the case throughout an arc of 210°—an impossible result, if the direction of reflexion were determined by that of the ocean-waves.

Rightly interpreted and followed out, these aërial echoes lead to a solution which penetrates and reconciles the phenomena from beginning to end. On this point I would stake the issue of the whole inquiry, and to this point I would, with special earnestness, direct the attention of the Lighthouse Board of Washington. Let them prolong their observations into calm weather: if their atmosphere resemble ours—which I cannot doubt—then I affirm that they will infallibly find the echoes strong on days when all thought of reflexion "from the crests and slopes of the waves" must be discarded. The echoes afford the easiest access to the core of this question, and it is for this reason that I dwell upon them thus emphatically. It requires no refined skill or profound knowledge to master the conditions of their production; and, these once mastered, the Lighthouse Board of Washington will find themselves in the real current of the phenomena, outside of which—I say it with respect—they are now vainly speculating. The acoustic deportment of the atmosphere in haze, fog, sleet, snow, rain, and hail, will be no longer a mystery: even those "abnormal phenomena" which are now referred to an imaginary cause, or reserved for future investigation, will be found to fall naturally into place, as illustrations of a principle as simple as it is universal.

While this Preface was passing through the press, the intelligence of the loss of the Schiller thrilled through the land. I look forward to a time when such a calamity upon our coast will be a simple impossibility. It is in our power to make it so; and that power will, I doubt not, be promptly and wisely employed.

ROYAL INSTITUTION, *May*, 1875.

## TELEGRAPHIC DETERMINATION OF LONGITUDE.

By F. M. GREEN,

LIEUTENANT-COMMANDER UNITED STATES NAVY.

IN the construction of new charts for the use of navigators, as well as in the correction of old ones, the assignment of different latitudes and longitudes to the same point, by various authorities, has always been a source of difficulty and embarrassment.

The exact position of all prominent points on the coasts of the United States, as well as those of England, France, and other European nations, has been determined with great accuracy; but a large portion of the earth's surface is still very imperfectly and inaccurately laid down on marine charts.

The latitude of any point being determined directly by observation, and independently of the latitude of any other place, is less likely to be in error than the longitude, which can only be ascertained with

reference to the meridian of some other place; being measured by time, is determined by the comparison of the local time with the time at some other place, the longitude of which is known.

Discrepancies in the results of observations for the determination of longitudes seem unavoidable with most of the methods usually employed, such as transportation of chronometers from place to place, observations of the relative positions of the moon and stars, and observations of occultations and eclipses.

Until the completion of telegraphic connection between this country and England, the exact longitude of the Washington Observatory was quite uncertain. A great many transfers of chronometers across the Atlantic had been effected by the Coast Survey at a great expenditure of labor and money. Yet the result of the latest expeditions differed from that deduced by Prof. Newcomb from moon-culminations by more than three and a half seconds of time, equal to nearly a mile, the final telegraphic determination lying between the two results.

In other parts of the world, however, the discrepancies are much greater. On the southern shore of the Caribbean Sea, an uncertainty of five or six miles exists with regard to many positions, and some of the islands in the Pacific Ocean have had longitudes assigned them by different surveyors within the last fifty years differing by as much as twenty-seven miles.

Where, however, chronometers have to be carried only a short distance from an established meridian, the results are much more accurate. In 1852, the longitude of Key West was measured by Coast-Survey officers from Savannah (previously established by telegraph from Washington), and was found to be 81° 48′ 30.″7. In 1873, by telegraph, Washington to Key West 81° 48′ 27.″2. It will be seen that the difference between these results is only 3.″5, equal to about 100 yards, and that the statement lately published in Appletons' Journal, that the recent telegraphic determination showed the former position to be several miles in error, is incorrect.

Of late years the establishment of telegraphic connection between so many points of the earth's surface, both by submarine cable and by overland lines, has added to the modes of determining longitudes another, by far the most simple, elegant, and accurate.

This method can, however, only be used between places having telegraphic communication with each other; but the exact determination of these meridians renders easy the correction of errors in the longitude of neighboring places.

The establishment of differences of geographical longitude by the electric telegraph and of geographical latitudes by the zenith telescope constitute two of the most important improvements in practical astronomy of modern times, and both have had their origin in the United States. To the skillful and indefatigable astronomers of the Coast Survey and those of the corps of United States Engineers are

due the introduction and perfection of the instruments and methods now employed, which make the results so accurate and the work so simple. "Among the very earliest of the astronomers to introduce this method of measurement was the lamented Captain J. M. Gilliss, U. S. N., who determined in this way the difference of longitude between Santiago and Valparaiso, Chili."

As soon as the Atlantic cable was laid, in 1866, the Superintendent of the Coast Survey took advantage of the opportunity to establish, by way of Newfoundland and Ireland, the difference between the meridians of the British Islands and those of the United States.

In 1869–'70, a similar determination was made by different observers through the French cable from Duxbury, Massachusetts, to Brest. Again, in 1872, the measurement was made through the same cable, using the island of St. Pierre, in the Gulf of St. Lawrence, as an intermediate station.

The exquisite accuracy of the results of these measurements is demonstrated by their accordance. Referring them to the station of the New York City Hall, the resulting longitudes are as follows:

| | | | | | |
|---|---|---|---|---|---|
| 1866—west | of Greenwich | $4^h\ 56^m\ 1^s.71$ | equal to | $74°\ 0'\ 25''.65$ |
| 1870— | " | " | $4^h\ 56^m\ 1^s.70$ | " | $74°\ 0'\ 25''.50$ |
| 1872— | " | " | $4^h\ 56^m\ 1^s.67$ | " | $74°\ 0'\ 25''.05$ |

The instruments in common use for making observations to ascertain the difference of longitude between two stations are, at each of the stations, a transit instrument, a break-circuit sidereal chronometer, and an electric chronograph; with the usual telegraphic sending and receiving instruments.

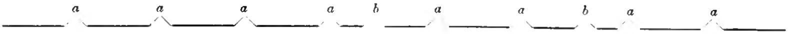
The transit instrument is a telescope, capable of being mounted accurately and firmly in an exact north-and-south line, so that the precise local time may be determined by the passage of well-known stars across the meridian.

The chronometer is adjusted to keep sidereal time and is furnished with an attachment by which the mechanism breaks an electric circuit every second.

Chronographs for the automatic registering of the exact time of any occurrence are constructed in various forms. Those generally used by astronomers in this country consist of a train of wheel-work driven by a weight, and causing a cylinder covered with a sheet of paper to make exactly one revolution in a minute.

A little carriage, to which a pen of peculiar construction is attached, moves upon wheels along the cylinder in the direction of its length, about one-tenth of an inch for each revolution of the cylinder, so that the pen records a perpetual spiral. The pen is so mounted as to have a slight lateral movement, and is so attached to an electro-magnet that, when the electric circuit in which it is placed is broken every second by the chronometer, which, with a small battery, is included in

the same circuit, the mark made on the chronograph-paper, instead of being a straight line, will be broken at regular intervals as shown at *a*.




By means of a little instrument called a break-circuit key, in the hands of the observer, and included in the same circuit, the electric current may be interrupted, causing the pen to make a similar mark as shown at *b*, on the occurrence of any event, such as the passage of a star across the wires of the telescope.

With a finely-divided scale the position of this arbitrary mark, with reference to the nearest second mark, may be accurately established, and the exact time accurately ascertained to within $\frac{1}{20}$ of a second.

By means of these instruments, the error of the chronometer is found at each station with great accuracy, and, the times shown by the faces of the chronometers being compared by telegraph, the difference of time and corresponding difference of longitude are readily deduced.

The time occupied by an electric impulse to traverse the wire from one station to another, and act upon the telegraph-instruments, though generally very small, is too great to be neglected, but is easily ascertained and allowed for.

Suppose *a* to be a station, one degree of longitude east of another station *b*, and that at each station there is a clock exactly regulated to the time of its own place, in which case the clock at *a* will be, of course, four minutes faster than the clock at *b*. Let us also suppose that a signal takes a quarter of a second to pass over the telegraph-wire connecting the two stations.

| | |
|---|---|
| Then if the observer at *a* sends a signal at exactly noon, by his clock, to *b*. . . . . . . . . . . . | $12^h\ 0^m\ 0^s$ |
| It will be received at *b* at. . . . . . . . . . . . | $11^h\ 56^m\ 0^s.25$ |
| Showing apparently a difference of time of. . . . . . . . . . . . | $3^m\ 59^s.75$ |
| Then if the observer at *b* sends a signal at noon by his clock.. | $12^h\ 0^m\ 0^s$ |
| It will be received at *a* at. . . . . . . . . . . . | $12^h\ 4^m\ 0^s.25$ |
| Showing an apparent difference of time of. . . . . . . . . . . . | $4^m\ 0^s.25$ |

One-half the sum of these differences is 4 , which is exactly the difference of time and of longitude; and one-half of their difference is $0^s.25$, which is exactly the time taken by the electric impulse to traverse the wire and telegraph instruments. This is technically called the "wave and armature time."

The error of each chronometer being ascertained by observations of stars at each station, and the difference of the chronometers being in this way shown by the exchange of signals, the difference of the local times, which is the difference of longitude of the two stations, is easily deduced.

Some English astronomers have objected that, where the line is, as

is usual in long land-lines, divided into lengths connected by telegraphic repeaters, the time of transmission will not be the same in both directions, and that the same effect would be produced in a submarine cable having an imperfection or leak nearer one end than the other. Experiments, however, by the Coast Survey on the long line from Washington to San Francisco indicate that this objection, though theoretically true, is of no practical importance.

Upon land-lines the time-signals sent can be recorded directly on the chronograph by putting it in the telegraphic circuit; but, with submarine cables, the electric impulse transmitted is not strong enough to act upon the electro-magnets of the chronograph-pen.

For telegraphing with weak impulses over submarine lines a very beautiful device was invented by Sir William Thomson, and is now in general use.

To a delicately suspended magnet, surrounded by a coil of fine covered wire, a small mirror is attached. From this mirror a beam of light from a lamp is reflected on a scale in a dark room. When no currents are being sent over the line, this beam remains at rest; but, when, at the sending station, either of two keys is pressed, a positive or negative current, as the case may be, is sent through the cable, and through the coil surrounding the magnet, causing the magnet with its mirror to turn and to deflect the ray of light to the right or left.

When the signal arrives and is perceived, the observer touches his chronograph-key, thus recording the time of its arrival.

The completion of the West India and Panama Telegraph Company's cable in 1873, and the certainty that serious errors existed in the geographical positions of many places in the West Indies and South America, caused Commodore R. H. Wyman, U. S. N., Hydrographer to the Navy Department, to turn his attention to the outfit of an expedition which should seek to determine with all possible accuracy the latitudes and longitudes of points connected by telegraph in that part of the world.

The authority of the Navy Department was readily obtained, and the necessary preparations were commenced in the spring of 1873.

In order that the work might be accomplished with economy, as small a vessel as possible was desirable, the Fortune, a strong iron tugboat of 300 tons, being selected and prepared. Although this little vessel carried the officers and men of the expedition safely, she was found to be too small to encounter heavy weather at sea with any degree of comfort.

The astronomical outfit was superintended by Mr. J. A. Rogers, of the Hydrographic Office, and was in all respects satisfactory.

The telescopes used were constructed at the repair-shop of the Hydrographic Office for the purpose, and were a combination of the transit instrument with the zenith telescope, a modification working admirably in practice, and first suggested by Prof. C. S. Lyman, of

Yale College. These instruments were so constructed that the eye-piece was at one end of the horizontal axis, a prism at the junction of the axis and telescope-tube reflecting at a right angle the rays from the object-glass, thereby enabling the observer to direct the instrument upon stars of any elevation above the horizon without change of position.

The command of the expedition was given to Lieutenant-Commander F. M. Green, U. S. N., and it was intended that the work should be commenced in the winter of 1873–'74; but the non-completion of the instruments and the probability of trouble resulting from the Cuban outrages interfered with this plan, and the Fortune was temporarily employed as a tender to the squadron at Key West.

Upon the dispersion of the assembled squadron in April, 1874, Lieutenant-Commander Green was directed to complete a survey of the Mexican Gulf coast, commenced by the United States steamship Wyoming. This work employed the time till the following August, when the Fortune returned to Washington, and was at once refitted for the prosecution of the original design.

Fortunately for the success of the work, the services of Mr. Miles Rock, formerly of the observatory at Cordova, were secured as principal astronomical assistant; and the Fortune sailed on the 24th of November, 1874, from Hampton Roads for Jamaica.

Upon arrival at Kingston, definite arrangements were made with the manager of the telegraph cables, the gratuitous use of which had been offered very promptly and courteously by the London board of directors.

As it had been decided to commence the work by measuring between Panama and Aspinwall, the Fortune sailed for the latter place on the 9th of December, arriving on the 12th.

Portable observatories had been constructed, to shelter the instruments and observers, and were immediately set up at Panama and Aspinwall upon obtaining permission from the local authorities.

Throughout the work the same general system was pursued, and was briefly as follows: As soon as practicable after the establishment of a party at each station, the work was commenced by observing stars on five clear nights, from 8 to 10 P. M., and from 11 P. M. to 1 A. M. for determining the errors of the chronometers, and during the hour from 10 till 11 P. M. exchanging time-signals between the two stations. This was effected as follows:

Telegraphic communication being established between the observatories, the senior observer sent a preparatory signal at ten seconds before the completion of a minute by tapping his key several times in quick succession; then exactly at the even minute, pressing his key again for about a quarter of a second, and repeating this signal at intervals of five seconds till the completion of the next even minute. The hour and minute when the first signal was sent were then tele-

graphed to the receiving station and repeated to insure correctness. The time of arrival of these signals was recorded by the chronograph at the receiving stations, and five similar sets were exchanged in each direction, making sixty-five comparisons each way.

After five nights of this work, zenith telescope observations of pairs of stars were made on four nights for latitude.

In this way, during the winter, the stations of Panama, Aspinwall, Kingston, Santiago de Cuba, and Havana, were occupied, the exact difference of time between each station and the next and the latitude of each being ascertained. It was intended to continue the work to Key West, thus connecting with a Coast Survey station, but the occurrence of yellow fever among the crew of the Fortune, and the breaking out of that disease at Key West, caused the postponement of this measurement till the next season.

By combining these ascertained differences of time, and applying the result to a determined position, the longitude of each place will be decided with a very small limit of error.

In addition to the above observations, the exact habitual error of observing, or relative personal equation of the two observers, must be ascertained and applied to the result.[1]

The method of star-signals, or the comparison of the times at which the same star passes over the meridians of two stations, is seldom used now, and therefore is not described in detail.

The authorities of each country visited extended the most gratifying courtesy and assistance to the officers of the expedition. Especially was this the case in the island of Cuba, where a Spanish naval officer was detailed to assist in the work.

On the 5th of April last, all work practicable during this season being finished, the Fortune left Havana, completing her cruise by arriving at the Washington Navy-Yard on the 12th of the same month.

The computation of the numerous observations made during the past winter is now being prepared, and, as soon as completed, the results will be published.

Some improvements and modifications, which the experience of the past year has suggested, will be made in the instruments and outfit, and the same officers in a larger and more commodious vessel will leave the United States during the coming autumn, to continue the measurements through the Virgin and Windward Islands to the coast of South America.

Although the naval surveyors of nearly all maritime nations (particularly the English) are constantly at work perfecting the knowledge of the earth's surface, it is believed that this is the first systematic naval expedition for establishing by this method secondary meridians to which other positions may be referred.

In connection with their preparations for observing the recent

[1] *See* Popular Science Monthly, vol. vi., p. 385.

transit of Venus, German astronomers have made some telegraphic measurements of differences of time in the East Indies; but the vast and constantly increasing net-work of cables nearly surrounding the earth will afford work for years to come, and will, in a way hardly contemplated by the projectors, add in a very great degree to accurate geographical knowledge.

# THE AMERICAN CHIPMUNK.

By CHARLES C. ABBOTT, M. D.

WITH the first sweet blossoms of the Epigæa, and long before the foremost warbler greets his old-time home with gleesome songs, our little chipmunk has roused himself from his long winter's nap, and, sniffing the south wind, as it whirls the dead leaves about, scampers to and fro while the sun shines, and dives into his winter-quarters, it may be for a whole week, if the north wind whispers to the tall beech-trees. But the blustering days of March give way in due time to showery April, and then, with more courage, "chip" faces the music of the winds, blow they from whatever quarter, and darting along the top rail of our zigzag fences, chatters, scolds, and calls at and to his equally noisy companions. They know full well that they have the summer before them, and, while determined to enjoy it, begin early and in good earnest to make arrangements for its coming duties. We watched several pairs of them from March to November, during the last year (1874), and our sketch is based on numerous notes made at different times.

Until the weather became fairly settled, and really spring-like in temperature, these little chipmunks did not frequently show themselves, and then only in the middle of the day. The occurrence of a cold storm they appeared to foretell by twenty-four hours, and resumed their hibernating sleep, becoming lethargic, and very difficult to restore to consciousness. A pair that we dug out in March, having two days before reëntered their winter-quarters and become again torpid, were apparently lifeless when first taken up in the hands, and not until after several hours' warming did they become lively and altogether themselves again. This seemed to us the more curious, in that they can respond to a favorable change in the weather in a short time, even when the thermometric change is really but a few degrees.

On the 3d of May a pair made their appearance in the yard of our residence, and took up their abode in a stone-wall having a southern outlook, and on the edge of a steep descent of seventy feet; which hill-side is thickly wooded, and harbors scores of these little chip-

munks, or "ground-squirrels," as they are more commonly called. From the fact of these little animals living wholly underground, and it being stated that their underground homes were quite elaborate in structure, we determined to wait until the pair in our yard had completed their excavations in and under the stone-wall, and arranged

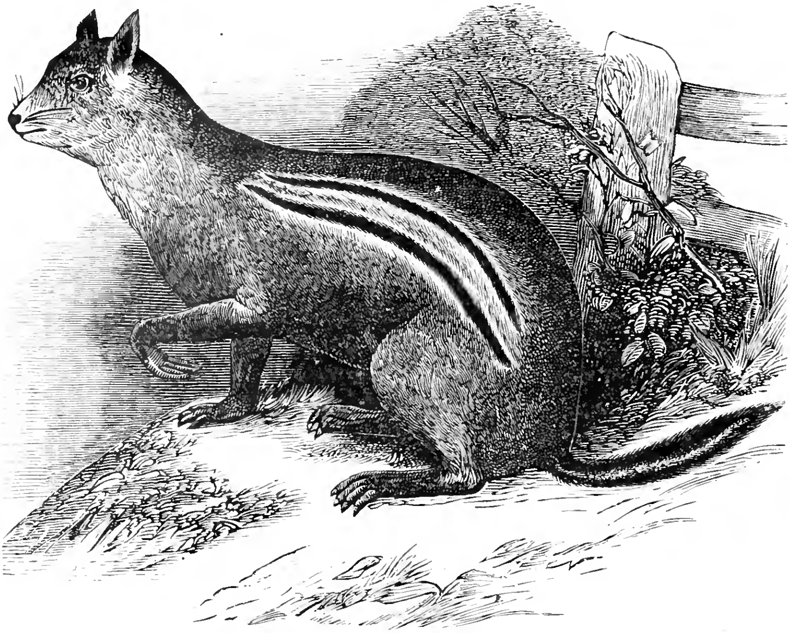


FIG. 1.—AMERICAN "CHIPMUNK" (*Tamias Lysteri*), HALF NATURAL SIZE.

their nest, which time we judged by their actions, and then seeking out the home of another couple, which was readily accessible, we undertook to expose the nest and its approaches. This we did on May 29th. The general character of the nest and its approaches are seen in the sketch. The nest contained five young, not more than forty-eight hours old. The two entrances were at the foot of a large beech-tree standing about six feet from the brow of the hill. The grass alone grew about the tree, and the holes on the surface of the ground were very conspicuous. No attempt at concealment had been made; but this was evidently because there is here almost a total absence of their particular enemies. Animals soon learn this fact, and their homes and habits vary with the knowledge. From the right-hand entrance to the nest was an intervening space of nine feet traversed by a cylindrical passage somewhat serpentine in its course, which made the distance really about twelve feet. The nest itself was oval, about twenty inches in length (the cut makes it appear too large), and ten inches in height. It was lined with very fine grass. We

had hoped to find several passages leading from the nest, and two or more "extra" nests, or magazines for storing away food, but no trace of them was to be found.

On the 23d of June, six young chipmunks made their appearance about the stone-wall in the yard, and to these, with their parents, we will now confine our attention. It puzzles us now when we think of it, to imagine when this company of eight chipmunks took any rest. Very frequently during the summer we were astir at sunrise, but the chipmunks were already on the go, and throughout July they appeared to do little but play; which sporting, by-the-way, is very animated. They seem to be playing at what children know as "tag," i. e., they chase each other to and fro, and try not simply to touch, we should judge, but to bite each other's tail. The way in which they scamper along the tapering points of a paling fence is simply astonishing; but however mad may be their galloping, let a hawk come near, and in a moment every one is motionless. If on a fence, they simply squat wherever they may be at the time, and trust to remaining unnoticed. If on the ground, and not too far from their burrows, which is not often the case, they will dart to their nests with an incredible celerity, going, we believe, the whole length of their passage-way to the nest, turning about, and retracing their steps to the entrance, from which they will peer out, and, when the danger is over, reappear and recommence their sports. These little animals

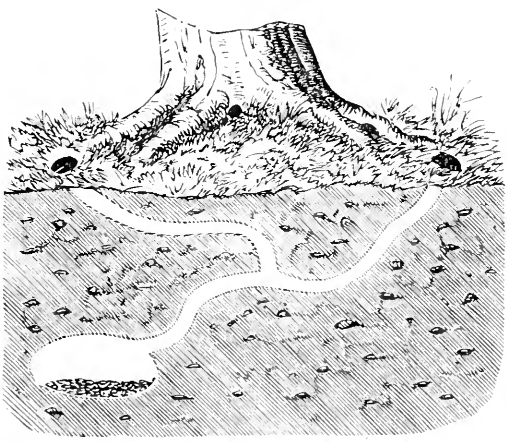


FIG. 2.—NEST OF "AMERICAN CHIPMUNK."

play merely for play's sake, and have no more important object in view than amusement. Indeed, so far as we have studied animal life, this indulgence in play, just as children play, and for the same reasons, is common to all animals. We have often seen most animated movements on the part of fishes that could be referred only to play.

That some work was accomplished during July by our eight chip-

munks, we have no doubt, as early in August we dug out a nest beneath an oak, on the hill side, and we found, besides the nest proper, two nest-like cavities, and in one of which—that most distant from the nest—was about a quart of yellow corn (maize). We judge, therefore, that these "magazines" were dug out by the chipmunks late in the summer, and similar ones, no doubt, were excavated by the chipmunks in the stone-wall. What they did with the dirt we cannot guess. Certainly not a particle of it could be found about their nests' entrances.

About August 15th they commenced to work in real earnest. Instead of playful, careless creatures, that lived from hand to mouth, they became very sober and busy indeed. Instead of keeping comparatively near home, they wandered to quite a distance, for them, and, filling both cheek-pouches full of corn, chincapins (dwarf chestnuts), and small acorns, home they would hurry, looking, in the face, like children with the mumps. This storing away of food was continued until the first heavy white frosts, when the chipmunks, as a member of Congress once said, went "into a state of retiracy."

The food gathered, we believe, is consumed in part, on their going into winter-quarters, they spending some time in their retreats before commencing their hibernating sleep. This belief, on our part, is based on the result of digging out a third nest on the 3d of November. The last time we noted down seeing a chipmunk belonging to a certain nest was October 22d. Twelve days after we very carefully closed the three passages that led to the nest, and dug down. We found four chipmunks very cozily fixed for winter, in a roomy nest, and all of them thoroughly wide awake. Their store of provisions was wholly chestnuts and acorns, and the shells of these nuts were all pushed into one of the passages, so that there should be no litter mingled with the soft hay that lined the nest. How long this underground life lasts, before hibernation really commences, it is difficult to determine; but as this torpid state does not continue until their food-supply is again obtainable out-of-doors, the chipmunks, no doubt, store away sufficient for their needs throughout the early spring, and perhaps until berries are ripe.

So much for the present year, now nearly passed away; but we are not done with the chipmunks yet, and next year, if all goes well, we purpose to follow the wanderings of the young brood of the past summer, for, we suppose, the old couple will not want them after spring once fairly comes again this way.—*Science-Gossip.*

# THE ENDOWMENT OF SCIENTIFIC RESEARCH.

BY RICHARD A. PROCTOR.

## II.

THE public endowment of science presents itself as a desirable supplement to the various means of maintenance considered in the previous part of this article. Those departments of science, in particular, which require costly instruments, which can only be pursued with the aid of trained assistants, or which, in other ways, involve greater expense than a man of ordinary means can afford, seem to require and deserve assistance from the national purse. On abstract principles, this use of the nation's wealth is strongly to be recommended. The subject is altogether worthy; the expenses would not be great, compared with others which are readily borne for purposes far less worthy; and this manner of supporting science commends itself to the respectful consideration of a nation accustomed, in spite of repeated disappointments, to regard state control as a surer resource than private efforts. I think every zealous student of science, to whom the subject might be submitted, would be apt, at a first view, to decide unhesitatingly that the endowment of science could not but be fruitful in good results.

So soon, however, as details are considered, and especially when candidates for the nation's money come forward and tell us precisely what they want, the matter assumes a different aspect.

So far as the source whence money could be provided for the endowment of science is concerned, there is little difficulty. The additional taxation required to meet all probable expenses would be so light as scarcely to be appreciable. But in truth a fund already exists out of which the cost of the endowment of science might be defrayed either wholly or in great part—the sums bequeathed in old times to the universities. Nor would this application of university property involve a departure from the purpose for which those sums were originally bequeathed. On the contrary, we have evidence to show that the universities were originally founded, not for educational purposes solely or chiefly, but for the advancement and preservation of knowledge. In the third report of the Commissioners for the Advancement of Science, we find that the witnesses examined were "on no point more united than in the expression of the feeling that it is a primary duty of the universities to assist in the advancement of learning and science, and not to be content with the position of merely educational bodies;" and the evidence quoted shows that this opinion was based on the fact that such was the original purpose of the universities—that, in fact, "the collegiate foundations of the universities were originally and fundamentally, although not absolutely and entirely, destined for"

that object. "This object" proceeds the report, "is certainly not less important in modern than [it was] in ancient society. In the middle ages, knowledge would altogether have perished if it had not been for such foundations, and it appears that now, from other causes, the pursuit of knowledge and of general scientific investigation is subject to very real dangers, though of another kind than those which then prevailed, and which make it very desirable to preserve any institution through which scientific discovery and the investigation of truth may be promoted."

Granting, however, first the desirability of endowment for science on abstract principles, and secondly that the necessary funds either already exist, or can be easily raised, we find ourselves in presence of the practical difficulties involved in the distribution of such funds. Decision must be made: first, as to the scientific subjects which shall be selected for endowment; secondly, as to the persons under whose supervision the funds for this purpose should be distributed; and thirdly, as to the persons to whom these funds should be dispensed.

On the first point, it is to be noticed that, since, for a long time, the administration of endowment would chiefly rest with non-scientific persons, the question of the practical value of different scientific subjects would at first be of primary importance. It is not to be expected that the value which scientific researches possess, apart from all material benefits they may bring with them, should be generally recognized. A principle of selection would have to be adopted at first which men of science would regard as essentially unsound. Nevertheless, little direct mischief would follow from this circumstance, though many advantages would for a time be lost. The limitation would exclude subjects worthy of the highest consideration: but these are already excluded; and many subjects now receiving no public support would be admitted. I apprehend that the most unfortunate result of this state of things would flow from the fact that persons desirous of securing money grants for a scientific subject of the non-productive sort might be tempted, rather than allow the nation to neglect it, to *imagine* material advantages from its cultivation. I am not aware that many instances exist whereby to illustrate this point, or indeed that as yet any appeal has been made for special endowment save in a single instance. But this instance chances to illustrate my meaning exceedingly well.

It will probably be admitted that the practically useful applications of astronomy are at least as well provided for by the nation as those of any other branch of science, not excluding chemistry or pure physics. Occasionally, also, government has provided, not without generosity, for astronomical researches little likely to lead to results of practical utility. Recent eclipse expeditions, and still more the expeditions for observing the late transit, are instances in point, seeing that it is almost impossible to conceive that mankind can derive any

direct benefits from a knowledge of the sun's surroundings, or of the distance, size, and mass of that luminary. But the nation makes no direct provision for researches into the physical condition and nature of the sun, the planets, stars, star-cloudlets, comets, the moon, and so on. Nor, probably, would an appeal for new observatories to meet this want receive general or effectual support at present. But, about three years ago, it was thought advisable, by two or three persons, to bring a scheme of this nature before the Astronomical Society, so as to secure the support of that body in submitting the matter to those in charge of the national purse. Of the fate of this scheme with the Astronomical Society I need say nothing, save that the Council were practically unanimous in rejecting it—only four voting in its favor. But I would direct particular attention to the nature of the argument used to obtain support for this scheme: "Permanent national provision," said its advocate, "is urgently needed for the cultivation of the physics of astronomy. If the study of the sun alone were in question, that alone would justify such a measure; for there can hardly be a doubt that almost every natural phenomenon connected with climate can be distinctly traced to the sun as the great dominating force, and the inference is unavoidable that the changes, and what we now call the uncertainties of climate, are connected with the constant fluctuations which we know to be perpetually occurring in the sun itself. The bearing of climatic changes on a vast array of problems connected with navigation, agriculture, and health, need but to be mentioned to show the importance of seeking, in the sun, where they doubtless reside, for the causes which govern these changes. It is, indeed, my conviction, that of all the fields now open for scientific cultivation, there is not one which, quite apart from its transcendent philosophical interest, promises results of such high utilitarian value as the exhaustive systematic study of the sun." [1]

[1] I quote from a paper by Lieutenant-Colonel Strange, a Fellow of the Astronomical Society. Of course this would not be the place to discuss his remarks. It need hardly be said that no astronomer has ever sanctioned such views, though many astronomers believe that an association exists between terrestrial relations and the phenomena of solar disturbance. It may suffice to remark here that the influence of changes in the sun's condition, as manifested by sun-spots and other solar peculiarities, must be infinitely less than the influence of those changes of aspect which produce the seasons; and yet our acquaintance with *these* changes leaves the "uncertainties of climate" still unexplained. How much less must be the significance of the cycles of changes in the solar spots! The chief of *these*, again, are already known, yet we are as far as ever from being able to predict the weather. Even the theories which have been advanced as to the connection between rainfall, prevalent winds, etc., and the spot-cycle, compel their advocates to assume contrary influences for different regions separated by nodal lines of no influence, which lines must also be assumed to shift their position from year to year—theoretical devices admitting of being most conveniently adapted to circumstances which would be fatal to any definite theory. Sir J. Herschel well remarks of such ideas that though "some rude approach to the perception of a cycle of the seasons may possibly be attainable, no person in his senses would alter his plans of conduct for six months in advance in the most

It would be fatal to scientific interests if such a mistake as this were often repeated. Yet we can have no assurance that the Government would not again and again be invited to support science on the strength of unfounded promises, if any wide scheme of endowment were adopted whose administration should be intrusted to non-scientific persons.

If the administration of the funds for scientific endowment were from the beginning intrusted to leading men of science, it is probable that correct scientific principles would be adopted for their guidance. But then a difficulty would arise which might prove even more serious than the mistakes of the unscientific. No one acquainted with the history or present condition of science, and with the relations which have existed and continue to exist among science-workers, can doubt that scientific managers of endowment funds would be repeatedly called upon to decide on the claims of methods or subjects to which they had conceived objections, and to vote respecting the candidature of scientific men against whom they entertained feelings of personal hostility. The first case can be illustrated by example, the other not so conveniently. Suppose Leverrier had been called upon to determine whether any sum from an endowment fund should be given prospectively for researches into the subject of transits of Venus, we may be sure (his actual course in the matter leaves no room for doubt) that his prepossession in favor of that method of measuring the solar system which is based upon the planetary perturbations would have led him to decide against any such grant. Many cases akin to this will occur to those familiar with recent controversies in various branches of scientific research. As to personal animosities, we may follow the convenient example of those writers who trace the faults of persons in high places down to a certain date, and leave the present time to the criticisms of future historians. It will be admitted that both Halley and Flamsteed were faithful servants of science; yet if either had had to decide on any question of awarding to the other some post of influence or emolument, it is to be feared, from what we know of their actual conduct toward each other, that the result would not have depended solely on scientific considerations. It may be hoped that there has been a change for the better since then, and that matters will improve still more hereafter. The advocates of rival theories, the leading teachers of different schools of thought, will one day, perhaps, be constantly on good terms with each other. Dissensions will be unknown in our scientific societies. The older men of science will be well pleased to see younger workers gradually modifying theories which had formerly seemed established forever, and the younger workers will never give unpleasant expression to the feeling that "authority" is not an absolutely certain guide in science. Jealousies and rivalries among those working in the same departments will gradually become

trifling particular on the faith of any special prediction of a warm or a cold, a wet or a dry, a calm or a stormy summer or winter."

things of the past. At present, all we can say is, that matters are improving at such a rate that . . . that they may be allowed, without disadvantage, to improve a little longer. If men of science were suddenly called upon to administer any extensive scheme of public endowment for science, this improvement might be checked, which would be unfortunate.

As regards the class of men who would come forward if science were endowed, much would doubtless depend on the position offered to the candidates for office, and on the qualifications demanded. In these days of competitive examinations, it seems probable that careful preliminary inquiry would be made into the proficiency of the candidates, at least in departments of learning associated with their special science. Again, it may be presumed that every office under the new system would have definite duties attached to it, even though matters were so arranged that ample time would be left for original research. It ought certainly to be arranged, moreover, that from time to time every holder of a salaried office should be called upon to give satisfactory proof that he was not wasting his own time and the nation's money. It would be unpleasant if a large salary were assigned for life to a zealous student of science, and then, by some accident, his zeal diminished. The mere loss of so much money annually would be of little importance to the nation; but the discredit to science would be a very serious matter. Unfortunately, those who ought to know assert that among the persons who seem most earnest in the cause of science, and who not only seem, but *are* exceedingly earnest in advocating the endowment of science, there are not wanting men who may be characterized as "scientific Micawbers, waiting for something to turn up." They may be recognized by men of discernment, because of their tendency to dilate upon their own work, to take credit for the work or methods of others, and to urge (anticipating, perhaps, the endowment of science) that large salaries should be given for the discharge of exceedingly indefinite duties. In any wide scheme for the endowment of research these persons would have to be carefully watched. The money wasted on them would be a matter of very little moment; but science would be degraded in the eyes of the world, and mischief, not easily reparable, would be wrought, if such men as these worked their way into the best-paid offices.

It may, perhaps, be urged that a system of payment by results might be established. Mr. Mattieu Williams, the ingenious author of "The Fuel of the Sun," in a letter commenting upon a leading article (mine, as it chanced) in the *Chemical News* for September 5, 1873, advances this as the only sound and natural principle of public endowment for science. The case seems very simple as he presents it: "If a fund for the payment of scientific research existed," he says, "the genuine worker might send in his bill with the paper communicating the results of his researches, and such a bill, after being fairly

taxed, should be paid like any other honest account, in a simple and business-like manner. The toiler in the workshop of science who reveals a new truth is a benefactor to the whole of mankind, has a fair and honest claim against the whole human race, and is entitled to draw a bill accordingly, which should be accepted and honored by his own country at least. Decent gratitude and common honesty demand so much from the nation. It should be done, and may be done, without opening a door to jobbery or any multiplication of corrupt and idle pensioners." I fear that though this might, perhaps, be managed in Utopia or the New Atlantis, it could scarcely be effected in England or any other country at present existing. The accounts that would be handed in to the minister of science under any such system would present a strange medley of real and false discoveries. His time would be chiefly occupied in objecting to undue estimates of results, and in endeavoring (hopelessly) to settle rival claims of contending discoverers. Besides, it is absolutely impossible to devise any scale of valuation for scientific discoveries. Conceive the state of mind of the minister of science, who, after disposing of claims for the quadrature of the circle, the discovery of perpetual motion, new cosmogonies, schemes of weather prediction, and the like, should suddenly find himself called upon to decide the money value of some great achievement in science, such as Newton's discovery of universal gravitation, or Kirchhoff's interpretation of the solar spectrum.

Whether the intrinsic value of any result, or the time and labor it had cost, were considered, the difficulty of determining how much should be paid for it would be alike insuperable. If the former were the test, who should determine the intrinsic value? The discoverer might perhaps overrate it, or, if he were really an earnest student of science, he would either underrate it, or be unwilling to make any claim at all. Others would, for the most part, be unable to estimate the result at its true worth, if it were really a discovery of importance. For the discoverer must commonly be in advance of his fellow-workers in the department of research to which his discovery belongs. He alone knows the relation of his discovery to work already accomplished in the same direction. Let any specialist, who has just obtained some notable result, be asked to name half a dozen experts in his own subject to whose opinion he would be willing to submit his discovery, and it will be found that he will with difficulty name half as many, and those not specially eminent in that subject.

As to the amount of time and labor devoted to any subject of scientific research, it is tolerably certain that the nation would object to any system of retrospective endowment based on that criterion. The ardent student of science gives many more hours of his time to his favorite subject of research than any government would be willing to pay for, at the present day, or for many years to come.

Past experience, not in scientific matters alone or chiefly, but gen-

erally wherever state maintenance has been provided for work which before had been carried on independently of the government, suggests that the wisest course would be to proceed tentatively. It is almost certain that any general scheme formed at the present time would hereafter have to be greatly modified, if not altogether abandoned. The time, indeed, has not yet arrived when the nation would look with satisfaction on any wide scheme of scientific endowment, even if Parliament could be persuaded to make adequate grants for such a scheme, or to authorize the employment for that purpose of funds available at the two universities. As to the action of our legislators, it may be remarked that possibly a favorable vote might be secured, if the more earnest supporters of endowment (who have shown considerable strategic skill in pushing their schemes) should choose a convenient season and convenient hours for bringing the matter before Parliament. But it is to be hoped that science will not be degraded by a line of action implying that the endowment of science requires to be urged as cautiously in Parliament as an act relating to contagious diseases. The most liberal grant would be dearly purchased by the disgrace which such a proceeding would bring upon science.

The nation is probably willing to see experiments made on the effect of endowment for special scientific purposes. If such experiments were made, we should gradually perceive whether wider schemes were likely to be advantageous to science, or whether dangers may not lurk in all such schemes. It might be found that endowment would tend greatly to increase the number of those entering on scientific pursuits, while widening also the range of scientific culture. It might be found, as some assert, that endowment would give the younger men a better chance of making good progress than they at present possess. Or, on the other hand, it might be found that the national endowment of science would tend only to advance scientific Micawberism, and that the real workers in science would be discouraged by seeing all the best rewards given for pretentious novelties, clever adaptations perhaps of their own discoveries. That, too, which Herbert Spencer has described as "the rule of all services, civil, military, naval, or other," might be found to operate with the scientific service also—the rule, namely, of "putting young officials under old," with its necessary "effect of placing the advanced ideas and wider knowledge of a new generation under control of the ignorance and bigotry of a generation to which change has become repugnant." This, "which is a seemingly ineradicable vice of public organizations, is a vice to which private organizations are far less liable; since, in the life-and-death struggle of competition, merit, even if young, takes the place of demerit, even if old."

It appears to me that those who really desire the advancement of science cannot too carefully or cautiously weigh the schemes now rife

for the endowment of physical research. Unquestionably, the abstract proposition that science is worthy of national support must be admitted as just. We may agree with Sir John Herschel in feeling "prepared to advocate or defend" (on abstract principles) "a very large and liberal devotion indeed of the public means to setting on foot undertakings and maintaining establishments in which the investigation of physical laws and data should be the avowed and primary object, and practical application the secondary, incidental, and collateral one." It is hardly necessary for me to say that I recognize the full weight of those considerations which have been urged in favor of wide schemes of endowment. Such schemes have, indeed, had few warmer advocates than myself, nor has any one been more outspoken in their support. But practical experience has taught me, I must confess, that dangers—and serious ones—surround them. Even while as yet they were in their infancy, mischievous tendencies began to show themselves which had certainly not been anticipated by those earnest students of science who first supported the general principle that science deserves the recognition of the state. Greedy hands were stretched out for the promised prizes. Jobbery began its accustomed work; and those who sought to check its progress were abused and vilified. If this happened when schemes for endowment were but mentioned, what evil consequences might not be looked for if those schemes succeeded? Deterred by the consequences of the first few steps they had taken in the direction of endowment, many of the most zealous workers in science now stand aloof. Before long, however, the real position of affairs will be known. If the present desire for the endowment of research is prompted by genuine zeal for science, we shall find that the warmest advocates of the scheme are not those who would themselves profit by it. But if, on the other hand, it should appear that the persons who now speak most earnestly about the endowment of science are in reality eager chiefly for their own preferment, or desire to secure posts of emolument for personal friends and adherents, then every real lover of science must desire the failure of such schemes, seeing that the cause of science could not fail to suffer, nor Science herself to be degraded, should they prove successful.—*Contemporary Review.*

## THE PYROPHONE.

By M. DUNANT.

SOUND is in general, according to natural philosophers, a sensation excited in the organ of hearing by the vibratory movement of ponderable matter, while this movement can be transmitted to the ear by means of an intermediate agent. Sound, properly called musi-

cal sound or tone, is that which produces a continuous sensation, and of which one can appreciate the musical value. Noise is a sound of too short a duration to be appreciated well, as the noise of a cannon, or else it is a mixture of confused and discordant sounds like the rolling of thunder. For a single sound to become a musical sound, that is to say, a tone corresponding to one of the intonations of the musical scale, it is necessary that the impulse and, consequently, the undulations of the air should be exactly similar in duration and intensity, and that they should return after equal intervals of time. In its change to the musical state, however dull and confused the noise may be, it becomes clear and brilliant. Like the diamond, after having been polished and cut according to the rules of art, it has the brilliancy for the ear which the former has for the eye. This is what takes place in singing-flames. Very imperfect in its beginning, hoarse, roaring, or detonating, it does not come nearer the musical sound, properly so called in the chemical *harmonica*, as it is termed, still, by means of reiterated trials, the sound of the single flame in the tube, the *lumen philosophicum*, as it is elsewhere called, can it be musically produced in every case.

It has long been known that a flame traversing a glass tube under a certain pressure produces a musical sound. The eminent *savant*, Prof. Tyndall, to whom the greater part of the deep questions in physics are no mysteries, has studied singing-flames, but it must be admitted that singing-flames have only penetrated into the dominion of art in consequence of the discovery made by M. Frederick Kastner of the principle which allows of their being tuned and made to produce at will all the notes of the musical scale, to stop the sound instantaneously and mechanically; as in keyed instruments, the sound is regulated and subdued as desired. It is thus that the modest *harmonica chimique*, *lumen philosophicum* of natural philosophers has, in the pyrophone, attained to the character of a real musical instrument; this happy result supports the remark that the observation in Nature of the phenomenon of sound may conduct man, if not exactly to the invention of music, at least to endow the art with resources which increase its power. The sound of the pyrophone may truly be said to resemble the sound of a human voice, and the sound of the Æolian harp; at the same time sweet, powerful, full of taste, and brilliant; with much roundness, accuracy, and fullness; like a human and impassioned whisper, as an echo of the inward vibrations of the soul, something mysterious and indefinable; besides, in general, possessing a character of melancholy, which seems characteristic of all natural harmonies. The father of this young philosopher, a member of L'Institut de France, and a learned author, who died in 1867, treating on cosmic harmonies, insists on this peculiarity:

"The harmonies of Nature," said he, "which, in their terrible grandeur as well as in their ineffable sadness, have ever charmed the philosopher, poet, and

artist, are most often stamped with a character of vague melancholy, from the influence of which the mind cannot escape. It is especially when the noise of the world is hushed that these powerful harmonies produce the most overpowering and poetical effects."

It characterizes, for example, the sound of the echo, the sound called harmonics, and many others which are included in the range of musical tones, defined further on under the name of *chemical and sympathetic music.* We have the most remarkable examples of these in the sound of the Æolian harp. Science, as well as philosophy, poetry, and musical art, is interested in the further study of these sounds. In Germany, Goethe and Novalis, in France, Jean Paul, and many others, have eagerly appreciated the bond which unites natural harmonies to the most elevated instincts, and to the most ideal aspirations of the human soul.

Prof. Tyndall has recognized the fact that, in order to render a flame musical, it is necessary that its volume be such that it should explode in unison with the undulations of the fundamental note of the tube, or of one of its harmonics. He also asserts that, when the volume of the flame is too great, no sound is produced; he demonstrates it, by increasing the flow of gas. Prof. Tyndall has also called attention to this fact, that, in order that a flame may sing with its maximum of intensity, it is necessary that it should occupy a certain position in the tube. He shows this by varying the length of the tube over the flame, but he does not specify the proportions which must exist between the flame and the tube for obtaining this maximum intensity of sound. M. Kastner's merit is in having shown that, when two or several flames are introduced in a tube, they vibrate in unison, and produce the musical maximum of sound when they are placed one-third the length of the tube, and, if these two flames are brought in contact, all sound ceases directly, a phenomenon M. Kastner demonstrates to be caused by the *interference of sounding flames.* Here is a question, lately scarcely thought of, of which M. Frederick Kastner has determined the laws, at the same time making a most remarkable application of them in creating an instrument which reminds one of, and may be mistaken for, the sound of the human voice.

A very simple mechanism causes each key to communicate with the supply-pipes of the flames in the glass tubes. On pressing the keys the flames separate, and the sound is produced (Fig. 1). As soon as the fingers are removed from the keys the flames join, and the sound ceases immediately (Fig. 2). These new experiments made by M. Kastner upon singing-flames should cause all makers of musical instruments to turn their attention to inventions connected with sound. If two flames of suitable size be introduced into a glass tube, and if they be so disposed that they reach one-third of the tube's height, measured from the base, the flames will vibrate in unison. This phenomenon continues as long as the flames remain apart, but the sound ceases as

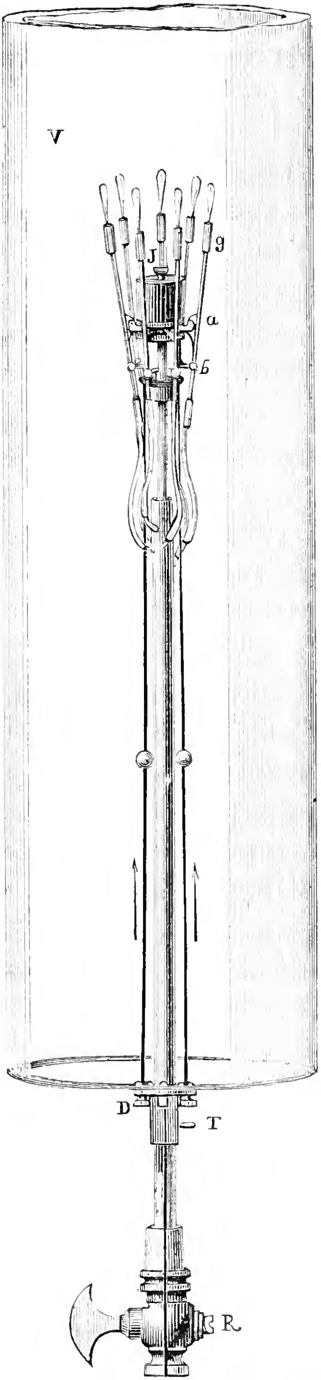



FIG. 1.—TUBE WITH SINGING-FLAMES, SHOWING MECHANISM BY WHICH THE GAS-JETS ARE MADE TO DIVERGE, AND THUS GIVE RISE TO THE SOUND.

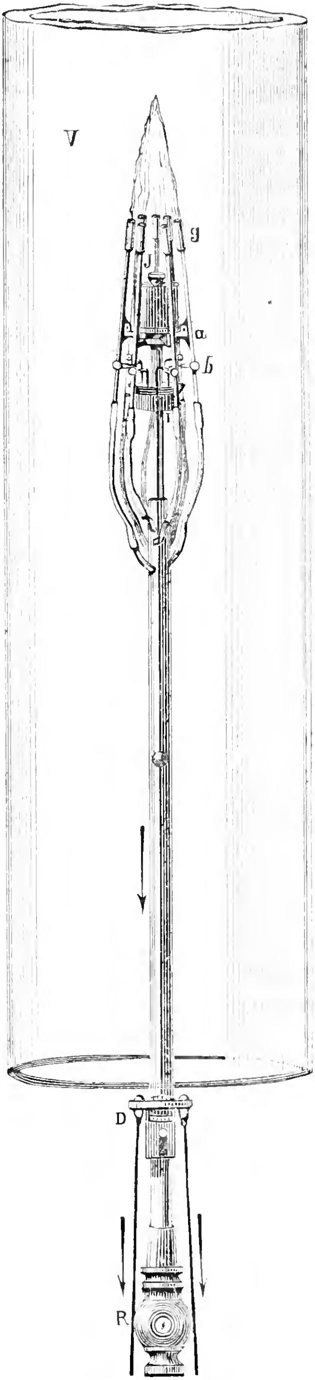



FIG. 2.—SAME, WITH FLAMES UNITED, WHEN NO SOUND IS PRODUCED.

soon as the two flames are united. If the position of the flames in the tube is varied, still keeping them apart, it is found that the sound diminishes while the flames are raised above the one-third until they reach the middle point, where the sound ceases. Below this point the sound increases down to one-fourth of the tube's length. If at this latter point the flames are brought together, the sound will not cease immediately, but the flames will continue to vibrate as a single flame would. M. Kastner, for his first experiments, used two flames derived from the combustion of hydrogen gas in suitably constructed burners. The interference of the singing-flames is only produced under special conditions. It is certain that the length and the size of the tubes depend upon the number of flames. The burners must be of a particular shape; the height of the flames does not exercise much effect upon the phenomenon. From a practical point of view, the numerous experiments effected by M. Kastner during several years have resulted in the construction of a musical apparatus of an entirely new principle, to which he has given the name of *Pyrophone* (Fig. 3); it may be called a new organ, working by singing-flames, or rather by vibrations caused by means of the combustion of these flames. This instrument may be constructed from one octave to a most extended compass.

The *British Review* humorously remarks that the pyrophone will naturally be valuable in winter, and that in America it has already been recommended to families as a means of warming small apartments, and perhaps an economical stove may be added to it for the culinary exigencies of straitened households.

The pyrophone will have in the future a poetical mission to fill in the music of concerts. A great number of composers and musicians have already admired this new organ performing by the singing of flames, or rather by vibrations determined by means of the combustion of these flames. They think it will be of great advantage in cathedrals and churches, as the most extended compass can be given to the instrument.

*L'Année Scientifique*, by M. Figuier, declares that the pyrophone is assuredly one of the most original instruments that science has given to instrumental music. In the large pyrophone which M. Kastner has constructed, and which they have not yet been able to bring to London, an artist can produce sounds unknown till the present time, imitating the human voice, but with strange and beautiful tones, capable of producing in religious music the most wonderful effects. So says *Le Journal Officiel de l'Exposition de Vienne.*

Journals and reviews abroad have unanimously mentioned with praise this new instrument, both from a musical as well as from a scientific point of view.

M. Henri de Parville, in *Les Causeries Scientifiques*, gives a large space to the consideration of "Singing-Flames," and states that "gas

music" made its *début* at the Vienna Exhibition of 1873. *La Nature* and *La Revue des Sciences*, edited by M. Tissandier, believe that this new instrument is destined to produce the most remarkable and unexpected effects in the orchestras of lyric theatres and in large concerts.

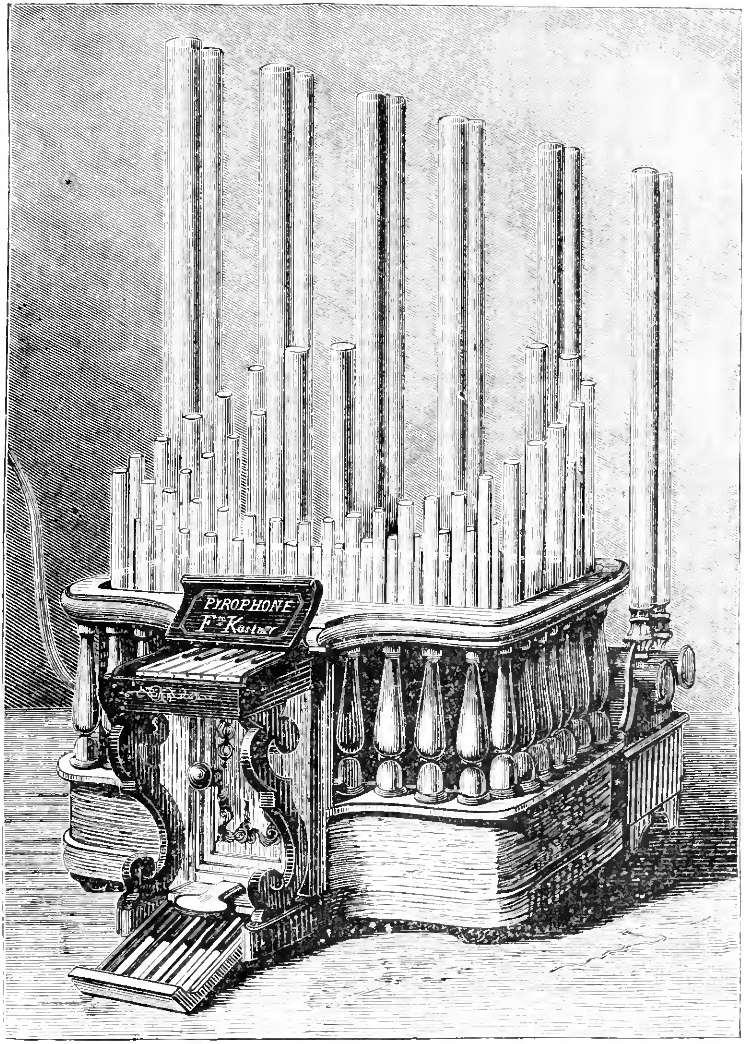



FIG. 3—THE PYROPHONE, OR GAS-ORGAN.

The chandeliers of the theatre, besides serving to light it, may be converted into an immense musical instrument:

"When the pyrophone is played by a skillful hand, a sweet and truly delicious music is heard; the sounds obtained are of an extraordinary purity and delicacy, recalling the human voice."

The inventor has prepared a large and beautiful singing lustre, with a dozen or fifteen jets, which can be placed in the richest or most comfortable drawing-room. This lustre may be used at concerts or balls, for it can play all the airs in dance-music. It will be worked by electricity, so that the performer who plays may be seated in a neighboring room. The effect will be perfectly magical. The future has other surprises for us for our houses. The most unexpected applications of scientific principles are daily the result of the skillful efforts of learned men.

Without reckoning Prof. Tyndall, who is so well known and esteemed on the Continent, many other learned men, English, German, Austrian (like Shaffgotsche), and Frenchmen, have already studied singing-flames, but no one had previously thought of studying the effects produced by two or several flames brought together, till M. Kastner, who, by means of delicate combinations and ingenious mechanism, has produced the pyrophone.

Frederick Kastner, the inventor of the pyrophone, showed from his earliest age a very decided taste for scientific pursuits. His parents, whose fine fortune permitted them to satisfy the taste of their son for study, gave him facilities often denied to genius. They frequently traveled: the first thing which arrested his attention was a railway; this pleased him much; he had a passion for locomotives, just as some children have for horses. He was only three years old when he examined the smallest details with a lively feeling of curiosity. Later on, when he tried to reason and explain his impressions, he overwhelmed with questions those who surrounded him, wishing to learn the mechanism of these great machines, and the mysterious force which sets them to work. But, what more especially charmed him was, when the train stopped at the station, the fiery aspect of the jets of gas emerging suddenly from the darkness. At this sight he shouted with delight; such was his enthusiasm, that he seemed as if he would jump out of the arms of those who held him, in order to rush toward the jets of flames, which exercised upon him a sort of fascination.

Steam and gas, in their modern application to locomotion and lightning, were the first scientific marvels which struck the mind and the sense of the child. He studied music under the skillful direction of his father. From the age of fifteen years, in studying gas particularly, his attention was directed to singing-flames. The mysteries of electricity were also at this time the object of his study. The researches to which he gave himself up carried him on to invent a novel application of electricity as a motive force. He patented this invention. On the 17th of March, 1873, the Baron Larrey, member of the Academy of Sciences of Paris, presented to the *Institut de France* young Kastner's first memoir on singing-flames, which laid down the following new principle:

"If two flames of a certain size be introduced into a tube made of glass, and if they be so disposed that they reach the third part of the tube's height (measured from the base), the flames will vibrate in unison. This phenomenon continues as long as the flames remain apart; but as soon as they are united the sound ceases."

Passing on to his experiments, M. Kastner thus gives his account:

"I took a glass tube, the thickness of which was $2\frac{1}{2}$ millimètres; this tube was 55 centimètres long, and its exterior diameter measured 41 millimètres. Two separate flames of hydrogen gas were placed at a distance of 183 millimètres from the base of the tube. These flames, while separated, gave F natural.

"As soon as the flames are brought together, which is done by means of a very simple mechanism, the sound stops altogether. If, letting the flames remain apart, their position is altered until they reach one-third of the total length of the tube, the sound will diminish gradually; and it will cease completely if the flames go beyond one-half the length of the tube; under this (one-half the length of the tube) the sound will increase until the flames are brought to one-fourth of the tube's total length. This latter point being reached, the sound will not cease immediately, even if the two flames are placed in contact one with the other; but the two flames, thus united, continue vibrating in the same manner as a single flame would.

"The interference of the singing-flames can only be obtained under certain conditions. It is important that the length of the tubes should be varied according to the number of the flames, the height of which has only a limited action or influence over the phenomenon; but the special shape of the burners is a matter of considerable importance.

"These experiments, which I undertook two years ago, induced me to construct a musical instrument, possessing quite a novel sound, which resembles the sound of the human voice. This instrument, which I term the Pyrophone, is formed by three sets of keys (*claviers*) disposed in a similar manner to that employed for the conjunction of the organ-key tables; a very simple mechanism causes every key of the different sets to communicate with the supply-pipes in the glass tubes. As soon as a key is pressed upon, the flames, by separating, create a sound; but when the keys are left untouched, the flames are brought together and the sound stops."

In consequence of this communication a commission from the Académie des Sciences de Paris was selected for the examination of this curious invention, consisting of Messrs. Jamin, Regnault, and Bertrand, three distinguished members of that Academy, who showed a lively interest from a scientific point of view in M. Kastner's discovery. After fresh experiments, M. Kastner has succeeded in substituting the ordinary illuminating gas for hydrogen gas in working this pyrophone, and his friend the Baron Larrey was again the interpreter to l'Académie des Sciences of this new discovery, which much facilitates the employment of the luminous musical instrument. M. Kastner thus expresses himself in his new report presented to the *Institut de France*, December 7, 1874:

"The principal objection which has been made to the working of the pyrophone is the employment of hydrogen gas. From a practical point of view, this

gas presents several inconveniences. It is difficult to prepare; it necessitates the use of gas-holders, whose size may be considerable. Besides, there is some danger in its use. I have therefore given up using hydrogen gas, and for a year I have experimented on the means of applying common illuminating gas to the pyrophone, which it is always easy to procure. In the first experiments which I attempted with two flames, with illuminating gas, in a glass tube, I was unable to obtain any sound, which proved unmistakably the presence of carbon in the flames. While the sound was produced in a very clear manner with the pure hydrogen gas, that is to say, without there being any solid foreign matter in the flames, it was impossible to make the tube with illuminating gas vibrate, when placing the flames in an identical condition. It was necessary, then, by some means or other to eliminate the carbon, a result at which I arrived by dint of the following method:

"When the flame of ordinary gas is examined, and this is introduced into a tube made of glass, or of any other material (metal, oil-cloth, card-board, etc.), this flame is either illuminating or sounding.

"When this flame is only illuminating, that is to say, when the air contained in the tube does not vibrate, it presents a lengthened form, and is pointed at the top. Besides, it swells toward the middle, and flickers on the least current of air. On the contrary, when the flame is sounding, that is to say, when the necessary vibrations for the production of sound are produced in the tube, its form is narrow, and large at the top. While the air of the tube vibrates, the flame is very steady. The carbon in a great measure is eliminated as if by some mechanical process.

"Sounding-flames proceeding from lighting gas are in effect enveloped in a photosphere which does not exist when the flame is merely luminous. In the latter case the carbon is burnt within the flame, and contributes in a great degree to its illuminating power.

"But, when the flames are sounding, the photosphere which surrounds each of them contains an exploding mixture of hydrogen and oxygen which determines the vibrations in the air of the tube.

"To produce the sound in all its intensity, it is necessary and sufficient that the whole of the explosion produced by the particles of oxygen and hydrogen in a given time should be in agreement with the number of vibrations which correspond to the sound produced by the tube.

"To put these two quantities in harmony, I have thought of increasing the number of flames so as to increase also the number of the explosions from the mixture of oxygen and hydrogen in the photospheres, and thus determine the vibration of the air of the tube. Instead of two flames of pure hydrogen, I put four, five, six, etc., jets of lighting gas in the same tube.

"I have besides observed that the higher a flame is, the more carbon it contains.

"I have then immediately been obliged to diminish the height of the flames, and consequently to increase the number so that the united surface of all the photospheres may suffice to produce the vibration of the air in the tube.

"The amount of carbon contained in the whole of the small flames will always be much less than the quantity of carbon corresponding to the two large flames necessary to produce the same sound. In this manner I have been able with separated flames to obtain sounds whose tones are as clear as those produced by hydrogen gas. When these flames, or rather when the photospheres which correspond to these flames, are put in contact, the sound instantly ceases.

The carbon of lighting gas, when the flames are sounding, is certainly almost entirely eliminated—in fact, it forms upon the interior surface of the sounding-tube at and below the height of the flames a very visible deposit of carbon, which increases while the air of the tube vibrates. I can now affirm that the pyrophone is in a condition to act as well with the illuminating gas as with pure hydrogen. The phenomenon of interference is produced exactly in the same condition with the two gases, the same flames occupy the same position in the tube, that is, the third part of the tube's length measured from the base. In addition to the phenomenon of interference, I believe I shall be able to describe a novel process by aid of which the sound produced by burning flames in a tube can be made to cease.

"Supposing that one or several flames, placed in a tube a third of its height (measured from its base), determine the vibration of the air contained in this tube; if a hole is pierced at the one-third of the tube, counted from the upper end, the sound ceases. This observation might be applied to the construction of a musical instrument, which will be a species of flute, working by singing-flames. Such an instrument, from a musical point of view, will be very imperfect, because the sound will not be so promptly or sharply stopped as when the phenomenon of interference is employed. If, instead of making the hole at the third, it is made at a sixth, the sound will not cease, but it will produce the sharp of the same note. In all these experiments I have clearly detected the formation of ozone while flames cause the air in the tube to vibrate. The presence of this body can, moreover, be ascertained by chemical reagents scientifically known."
—Given before the *Académie des Sciences*, December 7, 1874.

Prof. Tyndall, at a lecture on January 13th, at the Royal Institution, showed experiments, according to the new principle, with an apparatus of nine flames, which worked during the evening in tubes of different sizes.—*Journal of the Society of Arts.*

## ANIMAL PHOSPHORESCENCE.

AMONG the marvels which excite the admiration of the student of Nature, not the least strange is the group of phenomena known under the name of Animal Phosphorescence. We are so accustomed to associate light with heat, and to consider that fire of some kind is necessary to its production, that the imagination is appealed to with unusual force, when we find light proceeding from the body of a living animal. Yet, it is well known that the emission of light is not an uncommon characteristic among the members of the invertebrate divisions of the animal kingdom. Travelers have often expatiated on the beauty of the scenes which they have witnessed in the tropics, when the seas or forests have seemed to be illuminated by innumerable sparks of fire; and recent discoveries have shown that the luminous quality is even more common than was previously supposed. During the dredging expeditions of H. M. S. Porcupine in the years 1869 and

1870, so many of the deep-sea animals were found to be phosphorescent, that Prof. Thomson has suggested that the light necessary to the development of the eyesight which some of the specimens possessed may have had its origin in that source. In animal phosphorescence, as in all her works, Nature exhibits an immense variety in the forms in which she displays her power; in one case, the luminosity will be visible in a fluid secretion; in another, it will manifest itself through the action of a minute and complicated organ; one species of animal will shine with a yellow light; a second, with brilliant green; a third, with pale lilac; and we are acquainted with one instance in which the light changes successively to the chief colors of the solar spectrum. The causes which produce these phenomena are still very obscure. Although many forms of life are known in which the luminous quality is present, scientific men are not yet agreed on what the quality depends; and the purposes which the light serves in the animal economy are also little understood. But the phenomena themselves are often very remarkable.

Some strange theories were advanced to account for the phosphorescence of the sea, before the real cause was discovered. In 1686, an ecclesiastic, named Tachard, suggested that the ocean absorbed the sun's light by day, and emitted it again at night. About the same time, a better-known philosopher, Robert Boyle, endeavored to account for the same phenomenon by the friction which, he supposed, the rotation of the earth upon its axis caused between the water and the atmosphere. The problem was finally solved in 1749, by the discovery of luminous animalcules in the water of the Adriatic Sea; and a large proportion of the lower classes of marine animals are now known to be phosphorescent to a greater or less degree. Let us take the invertebrate divisions of the animal kingdom in their regular order, and briefly glance at one or two examples in each. Beginning with the simplest forms of life, the Protozoa, we find, in addition to certain Infusoria, the little jelly-like organism to which naturalists have given the name of *Noctiluca*, the phosphorescence of which is largely demonstrated around our coasts.

The radiated class of sea-animals possess high phosphorescent qualities. Star-fish, sea-pens, jelly-fish, sea-fans, sea-rushes, may be mentioned as cases in which the luminous quality is present among the radiata. We will take our examples from among the specimens captured during the expeditions of the Porcupine. On some occasions when the dredge was hauled up late in the evening, the hempen tangles which were attached to it came up sprinkled over with stars of the most brilliant uranium green; little stars, for the phosphorescent light was much more vivid in the younger and smaller specimens. The light was not constant, nor continuous all over the star, but sometimes it struck out a line of fire all round the disk, flashing, or one might rather say glowing, up to the centre; then that would fade, and a defined

patch, a centimetre or so long, break out in the middle of an arm, and travel slowly out to the point, or the whole *five rays would light up at the ends and spread the fire inward.* Doubtless, in a sea swarming with active and predaceous crustaceans, with great bright eyes, phosphorescence must be a very fatal gift. On one occasion the dredge came up tangled with the long pink stems of a kind of sea-pen, which were resplendent with a pale lilac phosphorescence like the flame of cyanogen gas; not scintillating like the green light of the star-fish, but almost constant, sometimes flashing out at one point more brightly, and then dying into comparative dimness, but always sufficiently bright to make every portion of a stem caught in the tangles or sticking to the ropes distinctly visible. In some places, nearly every thing brought up seemed to emit light, and the mud itself was perfectly full of luminous sparks. The sea-rushes, the sea-fans, and usually the sea-pens, shone with a lambent, white light, so bright that it showed distinctly the hour on a watch. In the neighborhood of the Madeiras, jelly-fish have been taken which emitted light in flashes, and the same phenomenon has been noticed in other parts, both in respect to jelly-fish, and, as we shall see, in respect to other animals.

Some of the most beautiful, luminous phenomena of the ocean are caused by animals belonging to the molluscous sub-kingdom, which is nearly as prolific in light-giving species as the Radiata. There is a shell-less mollusk which inhabits the Atlantic, in the neighborhood of the equator, and resembles a tiny cylinder of incandescent matter. It is microscopic in size, but prodigious numbers adhere together, until a tube from five or six to fourteen inches in length is formed, and the sea sometimes presents the appearance of a sheet of molten lava, from the number of these tubes which are floating in it. Moreover, a singular phenomenon is connected with this form of phosphorescence: the color of the light is constantly varying, passing instantaneously from red to brilliant crimson, to orange, to greenish, to blue, and finally to opaline yellow. Another highly phosphorescent species of Mollusca belongs to the family of the *Salpidæ*, which abounds in the Mediterranean and the warmer parts of the ocean. These individuals also swim adhering together in vast numbers, and produce the effect of long ribbons of fire, sometimes drawn straight in the direction of the currents, sometimes twisted and almost doubled by the action of the waves. In the Mediterranean their phosphorescence often resembles the light of the moon, giving rise to what the French term *une mer de lait.*

Luminosity is not so frequent a characteristic of the marine Articulata; nevertheless, it is exhibited by certain worm-like animals belonging to the class Annelida, and by a large number of the smaller Crustacea. In many instances the light takes the form of vivid scintillations similar to those emitted by the Medusæ, or jelly-fish, already mentioned. The appearance is sometimes very brilliant, when great

numbers of these organisms are present in the sea, the water, especially where it is agitated, being illuminated by sparks of light, varying in size from that of a pin's-head to that of a pea, and vanishing and reappearing in countless myriads. The late Prof. E. Forbes recorded instances in which he found individuals of a species of mollusk, whose visceral cavities had been deprived of their natural contents, to contain multitudes of minute crustaceans which emitted bright and rapid flashes.

If we now leave the marine world, and pursue our investigations among the inhabitants of dry land, we shall find the examples of phosphorescence much reduced in number. With few exceptions, the Articulata alone among land-animals possess this characteristic, and the class Insects furnishes us with by far the largest number of light-giving species. Thus, naturalists enumerate between two and three hundred kinds of luminous beetles, which are nearly restricted to two families, the *Lampyridæ* and the *Elateridæ*. We may take the common English glow-worm as a type of the former, and the famous fire-flies, said to serve the West Indian belles instead of jewels, as a type of the latter. In both, the organs which emit the light are very similar. Dissecting the abdomen of the glow-worm, two minute sacs of cellular tissue are seen, lying along the sides just under the skin. The cells are filled with a substance which, under the microscope, looks like soft, yellow grease. When the season for giving light is past, this yellow matter is absorbed, and replaced by the ordinary substance of the insect. A multitude of minute air-tubes surround and ramify through the sacs, terminating in a larger tube and a spiraculum, or air-opening in the skin. Free communication with the outer air is essential to the emission of the light of these two sacs, and we are thus able to account for the frequent disappearance of the glow-worm's lamp by the power which insects enjoy of closing their spiracula at will. But the *Lampyris* can in reality only partially extinguish its light; beneath the last segmentary ring of the abdomen a second pair of still more minute sacs are placed, likewise filled with yellow, greasy matter, and the light of these is not entirely under the insect's control. It may always be seen if the glow-worm be closely examined. The most curious feature connected with the organ has still to be mentioned; each of the points at which the light is visible is covered by a transparent, horny cap, divided into little hexagonal facets, and exactly similar in principle to an apparatus invented by man for increasing the diffusion of light.

The best known species of fire-fly, the *cocuja* of Spanish America and the West Indies, is an insect which resembles the common English black beetle in size, but it is dark-brown in color, and the divisions of its body are less deeply marked. The light is sufficiently strong to be of use to the inhabitants of the countries in which it is found. By inclosing three or four of the beetles in a glass bottle, a

lamp is obtained sufficient for ordinary household purposes, and travelers are said to fasten the insects to the toes of their boots, in order to illuminate the pathways at night. The light proceeds from four yellow spots upon the thorax, two of which are hidden by the wing-covers, unless the insect be in flight, when the brightness of the light is also increased by the quicker respiration caused by the motion. The luminous matter is more largely distributed than in the glow-worm, and, if the segmentary rings of the abdomen be gently pulled asunder, the light may be seen shining through the semi-transparent skin of the interstices.

Two East-Indian species of luminous beetles are especially worthy of mention. In the island of Singapore, a *Lampyris* is found which shines with an intermittent light. The insects cluster among the foliage of trees where the ground is damp and swampy, and, in accordance with some strange instinct, flash out their lanterns simultaneously. At one moment the tree will be dotted with bright sparks, which a moment later will have disappeared, excepting two or three. The intervals of darkness are about a second in duration. At these times the insects appear to be settled upon the leaves, and, if they are disturbed, they dart out at random, flashing their lights irregularly, and at shorter intervals. Borneo produces a species of glow-worm which shines with a triple row of lamps. It has been found crawling among dead-wood and leaves, the first row of lights being placed along the back, and the second and third rows along the sides.

Turning to another class among the land Articulata, we may briefly mention the phosphorescence of the centipede and that of the earthworm. Both phenomena may be seen in England, but are more common on the Continent. The centipede, which is tawny brown in color, and scarcely exceeds the tenth of an inch in diameter, is about an inch and a half in length. It frequents out-houses and arbors, where it may sometimes be found crawling along the ground, and searching for the insects on which it feeds. The phosphorescent property resides in a fluid which it secretes, and with which it can moisten the whole of its body. The light becomes more brilliant when the animal is irritated, and, if the fluid be received upon the hand, it will continue luminous for some seconds. M. Audouin, a French naturalist, residing near Paris, was witness of a remarkable appearance which was caused by luminous centipedes. He was informed that there were "earthworms" in a field near his house, glowing like red-hot coals. On going to the place to see, he found merely a few luminous streaks here and there upon the ground; but, when a spade was brought, and some of the earth thrown up, a beautiful spectacle presented itself. Great numbers of centipedes, which had collected together for some purpose, were unearthed, and the soil shone with the light which they emitted, the streaks remaining visible for many seconds, if the clods were crushed beneath the foot. Similarly, Prof.

Moquin-Tandon has recorded a case of the phosphorescence of earthworms, which he noticed on a garden-walk at Toulouse. The worms were about an inch and a half in length, and looked like little rods of white-hot iron.

It would be out of place in the pages of this journal to discuss the merits of theories which have been advanced to account for animal phosphorescence. As we have already said, Science has not pronounced any final decision on the matter. Some philosophers look upon the light as the result of the slow combustion of some combination of phosphorus contained in the animal secretions; others believe it to be a direct manifestation of vital force, acting through special organs, much in the way that electricity is produced in the torpedo or gymnotus. No doubt the problem will ultimately be solved as we advance in the study of comparative anatomy, and, in the mean time, many experiments have been made, in the hope of assisting the solution. It has been found that the luminous matter will communicate its peculiar property to liquids or solids with which it may come in contact. The light is extinguished by a cold or boiling temperature, or by strong stimulants; it also disappears *in vacuo*, but becomes visible again on the admission of the air; and it is increased by moderate heat, and by gentle stimulants. In respect to the glow-worm, the two smaller sacs of yellow matter which we described possess the curious property of shining uninterruptedly for several hours, after they have been removed from the living body, the light from other parts being extinguished immediately under similar circumstances. A simple galvanic current passed through water containing *Noctilucæ* produced no effect; but an electro-magnetic current, on the other hand, caused, after a short interval, a continuous and steady glow to issue from the water. The light disappeared at the end of a quarter of an hour, and could not be reproduced, the animalcules being evidently dead.—*Chambers's Journal.*

## THE GLACIERS OF NORWAY.

By Prof. HENRY M. BAIRD.

A VISIT to Switzerland has of late become so easy and frequent an undertaking, that the glaciers around Mont Blanc and the Jungfrau have lost much of their romance and all their novelty. Every tourist climbs the Montanvert to enjoy the sensation of walking over the Mer-de-glace in midsummer, and creeps under the Rosenlaui to admire the deep-blue color of its icy vault. There is, however, another country which, in the number and beauty of its glaciers, is a formidable rival of Switzerland; but, lying as it does, out of the

ordinary track of pleasure-travel, is far less known or appreciated. Norway may, in fact, be styled with good reason the country of the glacier. True, the height of its mountains does not approximate to that of the Alps. Only one or two summits exceed 8,000 feet in altitude, and this elevation is not much more than half that of Mont Blanc. But almost the entire country stands high above the level of the ocean, while its situation so far toward the north enables the snow-fields, which are the feeders of the glaciers, to retain their vast accumulations with little loss through rain or thaw.

If the reader will glance at a map of Norway, he will see that there are two well-defined divisions: the southern, a region not destitute of flourishing cities and towns; and the northern, a narrow strip consisting of little more than a succession of headlands and islands, stretching far within the Arctic Circle. Both divisions have their characteristic, that the mountain-ranges rise in the form of wide table-lands, extending for long distances in so nearly a perfect level "that, did roads exist, a coach-and-four might be driven along or across them for many miles." The very valleys that break up their continuity are unperceived by the eye, being overlooked on account of their narrowness; and the view is interrupted only by slight undulations, or by occasional mountains of no great size. Here it is that, summer and winter, the moisture which elsewhere descends in the form of rain, spreads the successive layers of the great *Sneefon*. Prof. Forbes, in the map accompanying his interesting work on "The Glaciers of Norway," indicates not less than eighteen of these "chief permanent snow-fields" to the south of Trondhjem, and nineteen in the narrow strip north of that city. It must not, however, be concluded too hastily that the climate of Norway is cold and inhospitable; for no greater contrast can be found between countries lying in the same latitude, than between Norway and Greenland. The influence of the Gulf Stream is nowhere more strikingly traced; for, if the summers in Christiania are comparatively cool, the winters are as warm as in many places far to the south of it. Indeed, it is the remarkably equable temperature of Norway which, while it prevents the harbors from being closed by drifting ice, like those of the opposite shores of Greenland, yet allows the line of perpetual snow to come down as low as 4,000 or 5,000 feet above the sea-level. For it has been conclusively proved that it is not so much the intensity of the winter's cold, as the amount of the summer's heat, that fixes the point where frost reigns supreme throughout the year. So it happens that, while the haven of Bergen, in latitude 60°, is frozen over only twice or three times in a hundred years, or about as often as the same fate befalls the Seine at Paris, the eternal snows cover the mountain-sides in the neighborhood of Bergen at heights at which the peasant on the Jura or the Alps pastures his flocks through the long summer months.

Of late, the *savants* of Norway have been giving to the world the

results of observations upon the glaciers which they enjoy such remarkable facilities for examining. About 175 miles in a direct line to the northwest of Christiania (which is not only the capital of Norway, but the seat of one of the best universities of Europe) is a spur of the principal range included between the two inlets of Sogne and Nord—fiords. Upon its top is the largest snow-field of Norway, which bears the name of Justedal (Jostedalsbræen). Its superior magnitude and its comparative nearness to Christiania have led to its selection by two of the most eminent geologists of the country as a subject of special study. In 1869 Prof. Sexe published, as the "Programme" of the university for the first *semester* of the preceding year, a paper on the great glacier of Boium; and, in 1870, M. C. de Seue, of the Meteorological Institute, gave to the world, as the "Programme" for the second *semester* of that year, a more extended account of his observations under the title of "Le Névé de Justedal et ses Glaciers." Some of the results of the researches of these gentlemen may be of interest even to those who would soon grow weary of purely scientific details.

This immense field of snow and ice measures over forty miles in length from northeast to southwest, and from four to seven miles or more in breadth, covering, with its dependencies, according to M. de Seue's calculations, not less than some 550 square miles. The *névé*, or snow-field proper, is by no means a dead level, but the inequalities of the rocky crags are, for the most part, concealed by the thick deposit of snow, which is supposed to be at least 150 feet deep on the average, while in places it certainly fills up depressions of twice that depth. Here the snow is granular, lying in distinct layers, the product of the storms of successive seasons, and rent with frequent fissures. The glaciers spring from the edge. Wherever the jagged cliffs with which that edge bristles fall away and leave ravines, there the snow-field seeks an outlet. The glaciers are, as it were, the rills by which the great perennial reservoir discharges into the valleys below. So numerous are they, that their exact number has never been ascertained. Of glaciers of the first class, or those which pour their icy streams quite down into the valley, there are twenty-four; but, if we also include in the enumeration the glaciers of the second class, or those which remain suspended on the mountain-sides, the number is counted by hundreds. Some of the second class, it may be noticed, seem almost entitled, by reason of their breadth and depth, to be included in the higher class.

Each glacier presents many of the same phenomena as all the rest. From the moment it leaves the parent *névé*, or snow-field, the constitution of the mass is different from that of recently-fallen snow. Compressed by the immense weight of the superior strata, that lower portion of the *névé* which feeds the glacier is, at the very start, transformed into a solid ice, whose particles are cemented by the alternate

melting and freezing which go on through all but the coldest weather of the year. Whether it is the pressure of the *névé*, or the irresistible expansion caused by the action of cold upon the water pervading its great mass, that drives off the glacier, is a question respecting which the most intelligent observers are by no means unanimous. Against the theory of *weight* as the motive power is urged the fact that occasionally the glaciers are not strictly adjacent to the superior snow-field, but separated from it by an intervening space of bare rock. When once it has emerged from the *névé*, the glacier becomes a stream of ice chiefly distinguished from a fluid river by the greater sluggishness of its current. How, it may be asked, can a mass of solid ice move in a fixed channel? The question was long unanswered. Indeed, it was only slowly that the truth forced itself upon the scientific world that it does actually move at all. And, the fact being conceded, the explanation is still not altogether easy. Prof. Sexe imagines that the plastic character of the glacier, as he has observed it in the neighborhood of Justedal, resides in the ease with which the ice fractures and the equal facility with which it reunites when fragments are brought together. Thus it is that, under the immense weight of the glacier, the glassy material of which it is composed is rent when brought into contact with some solid rock standing in its bed, and that the parted streams become one again as soon as the obstacle in their way is passed. So also it is that longitudinal fissures regularly form in the lower part of the glacier of Boium, when the glacier reaches a point where it can expand in the less contracted valley, while transverse fissures open in the glacier of Suphelle at a place where the inclination suddenly becomes more considerable than it was at first, and close up as soon as the slope is again a gentle one. M. de Seue, on the other hand, emphasizes the peculiar constitution of the ice of glaciers, that is, the ice which is formed by the compression and metamorphosis of snow "The ice of the glacier," he says, "is, as already remarked, composed of distinct particles. From a piece of this ice you can, as a general thing, easily remove the particles, one after the other, without injuring the surrounding ones; and, if you should find a particle which cannot be taken out without affecting the rest, you will still notice that you can move it a little relatively to the others without harming them. Take a piece of the ice of the glaciers of a convenient size, and, in trying (so gently that it does not break) to twist or bend it, you will notice at once that there is a little changeableness in the minute portions of which it is composed."

Both M. de Seue and Prof. Sexe reject the theory of expansion as failing to account for the phenomenon of the glacier's progression, and both virtually agree in ascribing that progression to the combined influence of the enormous pressure exerted by the glacier's weight and the melting produced by the air. Unfortunately for the former

theory—of expansion—it is difficult to see how it will explain the greater motion of the glacier in precisely that part of the year and of the day when the heat is the greatest, and the influence of expansion by freezing must necessarily be least operative.

The rapidity of the glacier's motion is much greater than we would naturally expect. By a course of very careful observations and measurements, Prof. Sexe found that, in the middle of July, 1868, the ice on the surface of the glacier of Boium, near the centre of the glacier and some distance from the lower end, moved $204\frac{1}{2}$ inches (Norwegian) in 211 hours. This was about $\frac{97}{100}$ of an inch per hour, and, if kept up during the entire year, would have given a total motion of about 707 feet. Here the motion was considerably greater by day than by night; in the former, exceeding $1\frac{1}{20}$ inch per hour, and, in the latter, being about $\frac{17}{20}$ only. M. de Seue, however, coming later in the same month, when the weather was less uniformly pleasant, found the average rate of progression of the same point very much diminished, viz., to less than $\frac{3}{4}$ of an inch per hour; and there is every reason to believe that, had these gentlemen been able to resume their observations in winter, they would have found that the motion during the cold weather is almost inappreciable. It is unnecessary to say that the difficulty of taking observations during half the year, on account of the temperature, and the glacier being covered over with deep snow, can scarcely be exaggerated.

It is not every part of the glacier which moves with even the rapidity mentioned. Toward the sides (and undoubtedly we should also find it so at the bottom, if we could get at it), the influence of friction can be detected retarding the motion. Near the lower end, also, the ice appeared to advance not more than one-third as fast as further up.

Of the numerous glaciers which M. de Seue describes as descending from the snow-field of Justedal, a number seem to be objects of great beauty. The photographic views which accompany his paper unfortunately fail to convey a very satisfactory idea of their appearance. The most considerable is the glacier of Trensbergdal, some nine miles long, and from two-thirds of a mile to nearly a mile in width. In several cases two or more glaciers meet, and, joining their contents, merge so thoroughly that they can be distinguished only by the *moraines*—lines of detached blocks of stone, torn from the rocks above in the downward course of the icy current, and which mark their edges even after their junction. Several are instances of what the French *savants* have called *glaciers remaniés*, the internal structure being altogether changed in consequence of their having been precipitated over ledges of rocks of considerable height. One of the smallest of the number is the glacier of Lunde, which is less than a mile in length, and only 100 feet in breadth. The interest attaching to it, however, lies in the suddenness with which it makes its spring

down from the snow-field. From the opposite side of the valley it appears like a cascade suddenly congealed in its fall; and the wonder of the spectator is excited by the apparent impossibility that such a mass of ice should thus remain suspended in mid-air. A nearer approach dispels the illusion, but scarcely the amazement of the beholder; for, after all, the inclination of the glacier is at least 45° with the horizon, nor could it maintain itself in this position but for the steep banks that inclose it, and the large mass of ice at its base which props it up.

All the glaciers of the first class are remarkable for the circumstance that their lower extremities are so little raised above the level of the ocean. While the glacier of Iökuls-fiord, in Northern Norway, is the only one in Europe, we believe, which actually comes down to the water's edge, there are several around Justedal that reach to within a few hundred feet of the sea's level, and one, that of Suphelle, to within 140 feet of it.

Of many other points developed in the valuable papers of Prof. Sexe and M. de Seue, which are of more interest to the student of physical geography and geology than to the general reader, we can enter into no discussion here.

## INFIRMITIES OF SPEECH.

WHAT is necessary in order to our communicating ideas by speech? It is necessary, first of all, that ideas call up their appropriate symbols; secondly, that we remember how to say words; and, thirdly, that our organ of speech be entire—by which is meant, the whole of the muscular apparatus which is brought into action when one articulates.

Now, each of these three capabilities is liable to injury from disease. When the first is affected, the patient forgets words, or uses wrong words, in which a connection with the right ones may be more or less traceable. In the second case, an individual may have lost speech entirely, or he may retain a few words. It is no use helping him out: having forgotten how to use words, he cannot repeat them when they are used in his hearing. In the third case, there is paralysis, it may be, of muscles of the mouth, of the tongue, the larynx, etc. This last form we will exclude from consideration here. The two former constitute the disease called *aphasia* (as at least understood by some writers), and the study of it makes us acquainted with some curious facts connected with the working of that wonderful organism with which we have been endowed.

There are well-authenticated instances of persons who suddenly

found that they could not remember their own names. An embassador at St. Petersburg was once in this case, when calling at a house where he was not known by the servants, and he had to apply to his companion for the necessary information. The names of common things are sometimes strangely forgotten. The wife of an eminent jurist who consulted Dr. Trousseau, of Paris, told him that her husband would say to her, "Give me my—my—dear me! my—you know," and he would point to his head. "Your hat?" "Yes, my hat." Sometimes, again, he would ring the bell before going out, and say to the servant, "Give me my um—umbrel—umbrel, oh dear!" "Your umbrella?" "Oh, yes! my umbrella." And yet at that very time his conversation was as sensible as ever. He wrote or read of, or discussed, most difficult points of law. A patient will often use a form of circumlocution to express his meaning; thus one man who could not remember *scissors* would say, "It is what we cut with."

It may be, however, that not only are the right words forgotten, but wrong ones are substituted. The mother-in-law of a medical man (we are told by Dr. Trousseau) labored under a very singular intellectual disorder. Whenever a visitor entered her apartment, she rose with an amiable look, and, pointing to a chair, exclaimed, "Pig, brute, stupid fool!" "Mrs. B—— asks you to take a chair," her son-in-law would then put in, giving this interpretation to her strange expressions. In other respects, Mrs. B——'s acts were rational, and her case differed from ordinary aphasia in that she did not seem to grow impatient at what she said, or to understand the meaning of the insulting expressions of which she made use. Crichton mentions the case of an attorney who, when he asked for any thing, constantly used some inappropriate term; instead of asking for a piece of bread, he asked for his boots, and, if these were brought, he knew they did not correspond to the idea of the thing he wanted; therefore, he became angry, yet he would still demand some of his boots or shoes, meaning bread. One gentleman (a patient of Sir Thomas Watson) would say "pamphlet" for "camphor." Another would say "poker" when he meant the "fire;" Dr. Moore, of Dublin, has recorded the case of a gentleman who completely lost the connection between ideas and words. On one occasion the doctor was much puzzled by his patient saying to him, "Clean my boots!" Finding that he was not understood, he became much excited, and cried out vehemently, "Clean my boots by walking on them." At length it was ascertained that the cause of disquietude was the shining of the candle in his face; and that the object of his unintelligible sentences was to have the curtain drawn. When this was done, he appeared gratified. In this case, it will be noticed, the patient formed complete sentences, the power of coördination and articulation was perfect, and the intelligence was apparently unimpaired. But sometimes, where articulation may be retained, what is uttered is perfect jargon. A gentleman in Dublin,

after an attack of apoplexy, was thus affected, and in the hotel where he staid he was mistaken for a foreigner. Dr. Osborn, with a view to ascertain the nature of his imperfection of language, asked him to read aloud the following sentence from the by-laws of the College of Physicians: "It shall be in the power of the college to examine or not to examine any licentiate previous to his admission to a fellowship, as they shall think fit." He read as follows: "An·the be what in the temother of the trothotodoo to majorum or that emidrate ein einkrastroi mestraits to ketra totombreida to ra from treido as that kekritest." Several of these syllables are difficult and unusual.

As indicated above, it is necessary to distinguish between the memory of *words* and the memory of *how to say* words. Where the latter memory is lost, the disorder is sometimes called *atactic aphasia.* The patient may retain a few words, and use only these. There was at the Bicêtre Asylum for many years a man who invariably used the monosyllable "Tan" when any question was put to him. (He went by the name of "Tan.") This, with the exception of an oath (S— N— d— D—!), composed his whole vocabulary. His history, long under observation, furnished some useful data with regard to the physiological relations of aphasia; but we cannot here dwell on this. Another instance, mentioned by M. Broca, was that of a man who had only four words besides his name (which he pronounced "Lelo" for "Lelong"); they were, *yes*, *no*, *three*, and *always.* He used *yes* and *no* at proper times, but he made use of the word *three* in order to express any number, although he knew well that the word did not always convey his meaning; and corrected the mistake which he made in speaking by holding up the proper number of fingers. Whenever *yes*, *no*, and *three*, were not applicable, he used the word always (*toujours*). M. Broca infers from this man's case—1. That he understood all that was said to him; 2. That he used with judgment the four words of his vocabulary; 3. That he was of sane mind; 4. That he understood written numeration, and at least the values of the first two orders of units; 5. That he had lost the faculty of articulate language alone. It is to this atactic aphasia alone that M. Broca limits the term *aphasia.* Another example of it may here be given from Dr. Trousseau. A lady came to consult him with her son, aged twenty-five. This young man could articulate two words only, *no* and *mamma.* "What is your name?" "Mamma." "What is your age?" "Mamma, no." He yet knew that he did not answer as he ought. He had taught himself to write with his left hand, the right being paralyzed, but had not got beyond signing his own name, "Henri Guénier." "Since you write your name," Dr. Trousseau told him, "say Guénier." He made an effort, and said, "Mamma." "Say *Henri.*" He replied, "No mamma." "Well, write *mamma.*" He wrote *Guénier.* "Write *no.*" He wrote *Guénier.* However much he was pressed, nothing more could be got from him.

There are various remarkable phases of this inability to articulate. One man in the Paris asylum would say "*Consisi;*" and it might be expected that he could easily say "*con-con*" or "*sisi*," but it was only after several days' trying that Dr. Trousseau got him to say the former, and he never could say "*sisi*" alone. Another aphasic patient, a woman, could say very well, "*Bonjour, monsieur;*" but could never be got to say "*Bonbon.*"

Aphasic patients are, as a rule, beneath the average of other men, as regards intelligence, and considerably beneath their former selves, when the comparison can be instituted. There is, however, a very rare form of aphasia in which the intellect is unaltered, memory is good, the patient writes easily, and expresses his thoughts correctly in writing as educated deaf-mutes do. The recovery of the art of writing (where it is recovered) is gradual.

The physiology of aphasia is a subject that has been a good deal controverted, but it now appears possible to explain most of the phenomena by the nature of lesions, and by the very constitution of the nervous system. The following representation of the facts (which we take, in the main, from an eminent French observer, M. Charles Richet) will convey some idea of what medical men hold on this subject.

The nervous system (let it first be understood) is formed of a central part, the brain and spinal cord, and of a peripheric part, the nerves. The nerves are simple conductors, while the central part perceives sensations and determines movement. Now, in this central part, the cerebro-spinal, inclosed by the cranium and vertebral column, as in a case, there are two distinct elements; an active element, and a conducting element. The white substance is the conducting element; the gray substance the active. The gray substance forms a thin column, which is the central part of the spinal cord, and is continued into the brain where it enlarges. The whole of this column is surrounded by white substance; and in the higher types of vertebrates we find added the so-called "cerebral convolutions." Here the white substance of the brain is folded in various directions, and its entire surface is covered with a thin layer of gray substance. To this elementary exposition it need only be added that the gray substance in brain or cord seems to be formed, not by a single cord, but by a series of nuclei, or centres, placed end to end and connected together. These are sometimes called *ganglions*. It is in the outer gray substance that will, intelligence, instinct, seem to reside. If the upper part of the cerebral hemispheres be cut in a pigeon, the bird loses all activity: it is incapable of moving voluntarily. It is an automaton which flies when thrown into the air, which swallows when a grain is placed in its throat; but which is without consciousness. Its existence is purely vegetative.

If, instead of the superficial part of the brain, it be the gray axis,

the spinal cord, that is injured, all the nerves coming out from it are paralyzed; and, so long as the ganglion from which the respiratory nerves come is not affected, life is possible, however numerous the paralyses. Now, it appears that, for each of our functions, respiration, movements of the heart or of the eye, deglutition, etc., there is a special ganglion of the gray substance forming part of the central column, and charged with the regular coördination of the movements necessary to the accomplishment of this function. Thus, e. g., in order to voluntary swallowing, it is first necessary that the will determine movements of deglutition, then that this order be transmitted to the nervous centre of deglutition, i. e., a small body of gray substance which anatomists have called the *olivary* body (on account of its form), and which presides over this function.

Between these two centres, however, of which one is producer and the other coördinator, there is a third, the centre of impulsion. The central gray substance, expanding in the brain, forms two large ganglions surrounded entirely by white substance, except at their base, which is connected with the central axis. These two large cerebral ganglions are called respectively the *optic layers* and the *corpora striata.* It is they that determine the motor impulsion, that transmit to such and such a ganglionic nerve-centre the order to put itself in motion. Thus the nervous influx arising from will proceeds from the superficial nerve-cells to the ganglionic centres of the brain, then to the ganglionic centres of the spinal cord, issuing in regular movement. It is something like the case of an electric telegraph, with stations and intermediate relays.

Now, coming to aphasia, it seems to have been well established (from *post-mortem* examination) that there is a limited region of the superficial portion of the brain, on which the faculty of articulate language is dependent, and impairment of which gives rise to aphasia as understood by M. Broca. First of all, it is in the left hemisphere (a curious thing in an organ so symmetrical as the brain). Next, it is in the anterior part of this hemisphere; and, lastly, to be more precise, it is the third cerebral convolution. Agreeably with this, it is found that a great number of aphasic patients are paralyzed in the right side of the body. It must be understood that the nerve-fibres cross over from the left hemisphere.

We may regard the anterior convolutions of the left hemisphere as a sort of *logopoietic*, or word-forming apparatus, where the previously vague idea becomes precise and distinct, taking a word-form and becoming representative. Lordat distinguishes these two forms of intelligence as the interior *logos* and the exterior *logos.* It should be remembered that this conception is a pure hypothesis; but it is in accordance with the facts.

But, for a phrase thought by us to come to the ear of another, a second series of apparatus is required. This is the continuous chain

going from the periphery of the convolutions to the central gray column. The nervous influx first goes into those two large ganglions of gray substance, the *corpora striata* and the *optic layers*. Probably these organs transform the phrase thought into voluntary movement. From the *corpora striata* the vibration is transmitted along the central axis to the olivary bodies, which are the coördinating apparatus, and which regulate and direct the movement. From the olivary bodies proceed nerves to the lips, the larynx, the tongue, the pharynx, the palate—all the vocal organs concerned in production of language. Pathological facts teach us that these different apparatuses may be destroyed separately, and there is then involved the absolute loss of such and such a function.

Thus in a case recorded by Dr. Winslow, the man had retained the faculty of language; he could write the words and phrases which he thought of; but, when he tried to speak, he only uttered confused sounds. In this instance the olivary bodies were alone affected. The faculty of language remained intact; the vocal apparatus was not injured; but the apparatus of transmission was profoundly altered.

In other cases, again, it is the organ of thought itself that is diseased. There is an affection well known to physicians who study the insane, and which is called general paralysis. This disease begins in the periphery of the convolutions, which are devoured (so to speak) by a slow inflammation characterized by intermittent extensions. One may take account of the disorders it causes by the state of intelligence of the patients. At first the inflammation produces an intellectual excitation, which expresses itself in mad acts. Each time a fresh access of madness is observed, one may pretty surely infer a new extension of the disease. But at length, when the whole outer surface of the hemispheres is destroyed, there is no longer either thought, or will, or instinct; the unhappy subjects are plunged in a state of somnolence and stupor, from which nothing can rouse them. They do not speak, because the organ of thought no longer exists.

It is probable, then, that between the organ of thought and the vocal organ there is a third organ—the organ of words, and it is a lesion of this which properly constitutes aphasia.—*English Mechanic.*

## ARCTIC ICE-TRAVELS.

By CLEMENTS R. MARKHAM, F. R. S.

FORMERLY exploration in the arctic regions was entirely performed by ships. On one or two occasions only were sledge-parties dispatched for the purpose of discovery, and then on a very reduced scale. During the search expeditions, however, after Sir John Franklin and his gallant companions, the system of sledge-trav-

eling was matured, and has now, owing to the genius of McClintock, Mecham, Hamilton, Osborn, and Richards, reached a high state of perfection. In fact, in these days the sledge must be regarded as *the* principal means of arctic exploration, and the ship only as the auxiliary. It is to Sir Edward Parry that the introduction of sledge-traveling is due, but the very primitive and cumbrous machines used by him, during his many successful voyages to the arctic regions, are no more to be compared with the light and useful sledges which are being constructed from the designs of Sir L. McClintock for the expedition of 1875 than is a brewer's dray to a light gig. We propose to institute a comparison between the modes of traveling past and present, and to describe the work that will fall to the lot of an exploring expedition during the space of twelve months. The best route for polar exploration is the one that has been so unanimously advocated by all arctic authorities both of our own and other countries, and the one that is to be adopted by the expedition about to leave our shores. There are many reasons why the route *via* Smith Sound is superior to and more advantageous for polar exploration than any other. We know that the United States exploring-ship Polaris succeeded by this route in reaching a very high northern latitude—in fact, the highest latitude that a ship has ever attained, and that in a remarkably short space of time and with perfect ease. The shores of this narrow sound are teeming with animal life. In Dr. Hayes's expedition upward of 200 reindeer were shot during the winter, walrus and seals were abundant, and there were quantities of ducks and little auks in the summer. Where the Polaris wintered herds of musk-oxen found pasture, rabbits abounded, and large flocks of birds came northward in the summer months. This in itself is of the utmost importance, as with well-organized hunting-parties, such as will be formed on board our exploring-ships, the crews will be supplied with fresh meat. The Smith Sound route is the best adapted for exploration by sledges, and in case of mishap or any unforeseen accident befalling the ships, it would simply be a matter of time for the ship's companies to travel south and reach the Danish settlements, or one of the Scotch whalers that annually frequent Baffin's Bay. The importance of reaching in the ships a high latitude lies in the consideration that every ten miles made good in the ship toward the north is two days' sledge-traveling saved. The ships ought to leave England in the month of May or June. In a fortnight Cape Farewell, the south extreme of Greenland, would be reached, off which the first ice is invariably met. This in a great measure consists of small, detached fragments, probably broken off the land-ice, with which Greenland at the early part of the year is surrounded, by the motion of the waves. Icebergs are also fallen in with in this locality. The scene on a fine clear day in Davis's Straits, to one visiting these regions for the first time, is indeed very grand. Huge icebergs sailing majestically along, in every conceivable

shape and form, at times making the navigation so intricate as to call forth the utmost vigilance and watchfulness from those on board, their edges adorned with pendent fringes of icicles, while the bright blue and green tints reflected from these huge mountains of ice tend to render it a scene such as is hardly to be realized by those who have never witnessed it. The Danish settlement of Lievely, or Godhavn, at the southwest extreme of the island of Disco, and Upernavik, the most northern settlement, are reached, dogs are purchased and taken on board, Esquimaux dog-drivers engaged, and the necessary skins and dog-food procured.

Now commences the first really serious work of the exploring ships. One day's run from Upernavik and Cape Shackleton is reached, from which is sighted the dreaded floe-ice of Melville Bay, a spot which, until the introduction of steam, has proved fatal to many a gallant bark. To an inexperienced eye this ice seems of an impassable and impenetrable nature, but to those acquainted with ice-navigation a lead may appear through which the ship is steered. Much depends on the wind in making a passage through Melville Bay. If it is calm, or if the wind is from the north, the ice loosens, and ships must then make the best of their time and push on speedily; but if the wind is from the south it causes the loose ice-floes of Baffin's Bay to pack against the land or fixed ice, and woe betide the unfortunate vessel that should be nipped between the two! The only means of escaping destruction is by cutting a dock in the land-ice and warping the ship into it. Steam, however, has of late years produced such a revolution in ice-navigation, that the animated scene of 200 or 300 seamen landed on the floe, busily employed in the operation of cutting docks, is now seldom or never witnessed. The last English Government Expedition, that of Sir Edward Belcher, took no less than five weeks going through Melville Bay, although the expedition was accompanied by a couple of steam-tenders, commanded by experienced and energetic officers. When Commander Markham went through Melville Bay in 1873, in the steam-whaler Arctic, the time occupied was only sixty hours, and last year the whole of the whaling-fleet succeeded in making the passage in three days! Such is the advantage we have gained by the aid of steam. Detention in Melville Bay is, even with a steamer, probable, but seldom for a long duration. When such is the case, ice-anchors are got out, and the ship is moored to the floe, waiting an opportunity for the ice to ease off. Perhaps it is only a neck of ice that prevents the ship from proceeding; in which case, with a full head of steam, the objectionable barrier is rammed, and the ship is forced through, emerging into the open water beyond. Even during these detentions the time may be beguiled in shooting looms and rotges, which are capital eating, harpooning narwhals and stalking seals, or in the more exciting sport of bear-hunting. Sport, together with the strange and novel scenery, and the beauties of the midnight sun,

makes life, even in Melville Bay, charming and enjoyable. In former days the monotony of the detention in this bay was indeed wearisome, and the laborious work of tracking the clumsy, unwieldy ship, or cutting docks in the floe, was fatiguing and irksome in the extreme.

In the latitude of Cape York the "North Water" is generally reached, and this, so far as we know, has always been navigable to the entrance of Smith's Sound, and to a much higher latitude.

We will now assume that the month of September has arrived, and that the expedition has succeeded in reaching, we will say by way of illustration, the latitude of 84°. We are, of course, anticipating an open season, and a most favorable and prosperous run. Bay or pancake ice, which is newly-formed ice, is now forming, and it is absolutely necessary to seek winter quarters. A snug harbor is, if possible, found, protected as much as possible from the prevailing northeasterly winds, and arrangements are at once commenced for securing and housing-in the ship. One part of the ship's company is told off for this latter duty, which consists in unbending the sails, unreeving running rigging, sending down upper spars, and housing the ship in with a covering made of tilt-cloth. This is spread on spars that are secured fore and aft between the masts about fifteen feet above the deck, sloping down to the bows and the stern, and ridge-ropes set up to the rigging, about seven feet above the bulwarks. One entry only is made as a gangway, on what would be the lee-side of the prevailing wind. An observatory is built, and an ice-wall made to inclose the ship, the space inside the wall being kept free and clear, to be used for exercise, and as a promenade during the winter months. In the mean time, the other part of the ship's company will be preparing the sledges, and making the necessary preparations for the autumn sledge-traveling, all of which will have been carefully organized beforehand.

We now come to the most important feature of arctic work, namely, the sledge-traveling, which was first introduced by the late Admiral Sir Edward Parry, but which is most indissolubly associated with the name of McClintock, whose perseverance and energy have brought this system of traveling to such a state of perfection that we rely chiefly on its aid to procure for the forthcoming expedition that success which all England heartily and eagerly desires, and hopefully anticipates. Before describing the arrangements for the autumn traveling, let us take a brief retrospect of the sledging undertaken by Parry fifty-five years ago.

Parry at Melville Island, in 1820, did not commence traveling operations until June. He used a cart, in all probability formed of the field-piece carriage and limber supplied to the ship. He was away only fourteen days, having traversed a distance of about 180 miles, averaging 12′ per diem. His party consisted of twelve, including himself, out of which five were officers. On account of the excessive glare caused by the sun on the snow and ice, the party traveled during the

night, when the sun was low. By this arrangement they had the advantage also of sleeping during the comparative warmth of the day. The daily allowance of provisions per man was 1 lb. of biscuit, $\frac{2}{3}$ lb. of preserved meat, 1 oz. of sugar, and $\frac{1}{2}$ pint of spirits. The total weight carried on the cart was 800 lbs., consisting of two blanket-tents, wood for fuel, three weeks' provisions, cooking-apparatus, three guns, and ammunition. In addition to this, each man had to carry a blanket-bag, a haversack with one pair of shoes, one pair of stockings, and a flannel shirt, weighing from 18 to 24 lbs. Their tents were made of blankets, with two boarding-pikes fixed across at each end, and a ridge-rope along the top, the lower parts of the blankets being kept down by placing stones on them.

In his attempt to reach the pole, in 1827, Parry started in the same month of June, with four officers and twenty-four men, with seventy-one days' provisions, in two flat-bottomed boats named the Enterprise and Endeavor, so constructed that they could be used as sledges, and drawn on the ice. They were 20 feet long, and 7 feet broad, with a bamboo mast 19 feet long, a tanned duck-sail, steer-oar, fourteen paddles, a sprit and boat-hook. Each boat, with stores, etc., complete, weighed 3,753 lbs., making the weight for each man to drag 268 lbs.! in addition to four light sledges, weighing 26 lbs. each. The boats were squarely built, without regard to shape or symmetry, their beam carried well forward and aft. In order to secure elasticity during the rough handling which they must needs encounter from frequent concussions with the ice, their frame was first covered with a water-proof coating, consisting of tarred canvas, then a thin fir planking, which latter was covered with felt, and outside a thin oak planking, the whole secured to the timbers of the boat by iron screws. On either side of the keel was a stout wooden runner, shod with metal, similar to that of a sledge, on which the boat would travel when being dragged over the ice. A spar, made of hide, was secured across the fore-end of the runners, to which the drag-ropes were attached. The daily allowance of provisions for each man was 10 ozs. of biscuit, 9 ozs. of pemmican, 1 oz. of cocoa-powder, and 1 gill of rum, besides 3 ozs. of tobacco per man per week. The fuel used was spirits of wine, of which 2 pints were used daily.

This was one of the most laborious and heart-breaking journeys that can be conceived, as, owing to the lateness of the season, the traveling was chiefly over loose pack, which on account of unusual heavy rain was broken and rotten; added to this, the hummocky nature of the firmer ice necessitated a constant packing and unpacking of their sledges, the same ground having to be traversed as many as three and sometimes four times. Parry nobly persevered, fighting against obstacles that would have daunted and appalled many a brave man, until it was known that the drift of the ice on which they were traveling was faster to the southward than the progress they were mak-

ing to the northward, and they were in consequence reluctantly compelled to abandon their project and return to their ship, which they succeeded in reaching after an absence of sixty-one days. Although before turning back the party had traveled over 292 miles of ground, their greatest distance from the ship was only 172 miles, so much had the set drifted them to the southward. Notwithstanding these obstacles, and the enormous weight which each man had to drag, the latitude attained by Parry on this occasion has never been reached by known man. The experience gained during this enterprise has shown us a great deal. It proved that the allowance of provisions for the amount of work required, and for the hardships endured, was insufficient; that the sledges were too cumbrous and heavy, and the weight that each man was required to drag was far in excess of his capabilities, and that the season was so far advanced as to cause not only the ice to be broken up, and thereby affected by the current, but the mild temperature had so rotted and thawed the surface of the floes on which they traveled, that the greater part of their journey was performed walking through sludge and water. As during his former sledge-journey in 1820, Parry preferred traveling by night, and resting during the glare and warmth of the mid-day sun.

The next authentic accounts of sledge-traveling we hear of are those parties organized by Sir James Ross in 1849 for the relief of Sir John Franklin, in which Sir Leopold McClintock, then a lieutenant, received his first initiation in that important branch of arctic work, which through his means has reached such an admirable state of perfection. But to what consequences did these pioneer expeditions lead? Experience had to be gained, and the privations and sufferings endured by those engaged in these early expeditions are now compensated by the lessons they have taught us. They started with two sledges, each drawn by six men, carrying with them their tent and thirty days' provisions. Other parties with more provisions followed on their route. They were away forty days, having accomplished a search over 500 miles of unknown country, but we are told that out of the twelve men that started, seven only returned in comparative health, the remaining five having quite broken down under fatigue. The party suffered severely from hunger, frost-bites, blistered feet, and rheumatic pains, caused by their continually walking through water on the ice and deep soft snow. Two of them, being unable to walk, were brought back on the sledges. Sir Leopold himself acknowledges that, after his return to the ship, he did not lose the sensation of *constant hunger* for a fortnight.

During the next expedition, that of Captain Austin, in 1851, from the experience which he had already gained in sledge-traveling, Sir Leopold McClintock, by adopting a system of fatigue-parties, was enabled to prolong his absence from the ship to eighty days, and to extend his journey to a distance of 900 miles. During this journey,

partly traveling over the same ground as Sir Edward Parry, he discovered the encampment of his predecessor, and found the remains of his broken cart, and the records left by him thirty years before. Even the remains of Parry's last feast, "a sumptuous meal of ptarmigan," lay strewed about in the shape of bones, by no means decayed, but merely bleached from exposure. McClintock and his gallant party returned to their ship after this long absence, reduced a little in flesh, but *not* in health or spirits. They had already benefited from the experience of former expeditions.

During the expedition of 1852, the last dispatched by Government in search of our missing countrymen, we find Sir Leopold McClintock in command of the steam-tender Intrepid, acting under the orders of Captain Kellett. On this occasion, Sir Leopold had, through the assiduous and constant exercise of his inventive talent, so improved on his former knowledge of sledge-traveling, that he was enabled to remain away from his ship for a period of 105 days, during which time he traveled over no less than 1,400 statute miles, and this, too, under no very favorable circumstances, as the ice over which he had to journey was old and unusually rugged, snow lay very deep, and Melville Island had to be crossed and recrossed, in addition to which, owing to the few men from whom he had to select his party, he was obliged to portion out to each man a much heavier load than had ever been attempted before. They were most fortunate in obtaining plenty of game. Musk-oxen, deer, and ptarmigan, were seen in abundance, and many shot, the fresh meat from which materially assisted in the preservation of the health of the party.

The words of Sir Leopold McClintock are very true, and very significant, in epitomizing the results of arctic ice-travel. He says: "Truly may we arctic explorers exclaim, 'Knowledge is power!' It is now a comparatively easy matter to start with six or eight men, and a sledge laden with six or seven weeks' provisions, and to travel some 600 miles across desert wastes and frozen seas, from which no sustenance can be obtained. There is *now* no known position, however remote, that a well-equipped crew could not effect their escape from by their own unaided efforts. We *felt* this, and by our experience, gained in a cause more glorious than ever man embarked in, have secured to all future arctic explorers a plan by which they may rejoin their fellow-men."

Before detailing the operations connected with the autumn sledge-traveling, it will be necessary to explain the construction of the sledge, and the amount of provisions and stores that will be required for an extended journey. We propose, therefore, to give an account of an eight-man sledge, provisioned and stored for a period of eight weeks, copied from Sir Leopold McClintock's notes. The following particulars describe, with considerable exactness, the equipment which is now being prepared in Portsmouth Dock-yard for use in the forthcoming Arctic Expedition:

The sledges are made of American elm, and the runners are shod with steel. The cross-bars are lashed to the bearers with strips of hide, which are well soaked in hot water and put on while warm and wet, so that when cold they will shrink tightly into their places.

The drag-ropes should be of two-inch whale-line, or better still of hemp or manila rope, which is lighter, six fathoms in length, and these could also be used for tent-ropes. They should be middled and the bight toggled to the span on the fore-end of the sledge. The span should be of the same size and description of rope, fitted to go with an eye over the end of the horn at the after-end of the sledge, rove through one or more grummets on the cross-bars, through a hide-strop round the runner, and taken well down below the foremost horns, so as to keep it as near as possible to the best angle of traction, namely, 15°. The bight of the span should be about three feet in front of the sledge, having a toggle and eye in the middle for the purpose of connecting the drag-ropes. To keep the contents from falling down between the cross-bars, two fore-and-aft lines are clove-hitched round each and stretched taut along—over these is laced a width of stout canvas, on which rests the sledge trough or load, and is called the sledge-bottom. The sledge-trough, although not absolutely necessary, is extremely useful, as it enables the sledge to be loaded more speedily, and prevents small packages from tumbling out; it is also most useful in the event of much wet. It is simply a canvas body in which the stores are packed, and weighs, without being oiled, eight pounds.

The drag-belts are made of light loose girth, three inches wide, long enough to go over a man's shoulder, having a strong eyelet-hole worked in each end, into which is spliced a piece of one-inch rope, having a thimble on it. Round this thimble is spliced a small piece of rope, having at its other end a bung toggle, usually a circular piece of copper. This is attached to the drag-rope after the manner of a Blackwall hitch, the advantage being that the man can detach himself at any instant. Turk's-heads worked on the drag-ropes point out where the men are to attach themselves. The sledge-lashings consist of about twenty fathoms of one and one-quarter inch untarred rope, and are used for lashing the lading on the sledge.

Too much care cannot be taken in the stowage and lashing of the sledge. The greatest weight should be over the centre cross-bar, diminishing toward the end, so that the sledge will rise easily and gradually, and descend in the same manner, when traveling over rough or hummocky ice. A well-packed, that is, a well-trimmed, sledge is dragged with less exertion, and less jerking to the men's shoulders, when going over rough ice, than one that has been carelessly packed. The lashings should be passed so tight that, should the sledge be upset and roll over, its contents would remain intact. It will be found convenient to fit a light cross-bar across each end of the sledge, for the purpose of spreading a light netting, on which to stand the cook-

ing-utensils, as they are usually the last things to go on the sledge and the first things to come off it.

Dog-sledges are of a smaller size, and the different fittings and gear are therefore proportionately small. The driver in a packed sledge usually walks behind, holding on to the back of the sledge with one hand while with the other he uses the whip, which latter has to be kept in constant use.

A most important auxiliary in sledge-traveling, and one which must not be omitted, is the sledge-sail; by its aid, with a fair wind, the men are greatly relieved in their laborious work of dragging. The mast is extemporized out of two tent-poles—which should, if possible, be of bamboo—used as sheers, the heads being connected by an iron band, on which is stropped the block through which the halyards are rove; the heels of the sheers are stepped into a thimble on each side of the sailing-thwart, which is placed across the sledge on top of every thing, immediately over the midship-upright, and is lashed down to the bearers. The object of having it so high is that a loftier sail may be spread. The tent-ropes are used as guys, and a hand lead-line as halyards. Each sledge should have what is called a "store-bag," made of light duck, and containing sail and sewing-needles, a palm, twine, thread, a ball of spun-yarn, two yards of green or blue crape, awls, waxed ends, lucifer matches, record-cases, tent-brush, clothes-brush, and spare wicks for cooking-lamps.

With an eight-man sledge detached for an extended journey of seven weeks the total weight of the laden sledge would be 1,646 pounds, being 235 pounds for each of the seven men to drag. If *all* the circumstances are favorable, Sir Leopold McClintock is of opinion that this is not too much; of course the men must be picked and well trained to sledge-work before setting out. Under no circumstances should this weight be exceeded, or even maintained for more than a very few days. When sledges are traveling in company, one gun each and much less ammunition will suffice. The sledges being prepared and every thing in readiness for a start, the men are assembled dressed in the following manner:

| | | SPARE. |
|---|---|---|
| 1 | Flannel or wove woolen frock. | |
| 1 | Thick Guernsey frock. | |
| 1 | Loose serge or cloth frock | 1 |
| 1 | Pair of good duffle (or box cloth lined with flannel) trousers. | |
| 1 | Light close duck jumper and trousers as "overalls." | |
| 1 | Pair of worsted stockings | 1 |
| 1 | Pair of wove woolen drawers | 1 |
| 1 | Pair of blanket feet-wrappers | 2 |
| 1 | Pair of wadmill boot-hose | 1 |
| 1 | Pair of moccasins | 3 |
| 1 | Pair of mitts | 2 |
| 1 | Welsh wig | 1 |
| 1 | Cap, veil, and face-cover. | |
| 1 | Comforter. | |
| 1 | Pair of colored spectacles. | |
| 1 | Pair of canvas boots | 2 |

Towel and soap, also a water-bottle and gutta-percha drinking-cup. Spare clothing in knapsack, altogether weighing twelve pounds.

The clothing supplied by Government to the various search expeditions was made of the most superior material, and was found excellent. It is hardly necessary to describe the different articles. Particular care should be exercised in the selection of under-clothing, which should be of the best and warmest substance. Outside clothing should fit loosely. In place of the overall jumper and trousers, which are used merely as "snow-repellers" to keep out the light snow-drift, a suit made from the skin of the moose-deer well smoked would be found advantageous; the jumper should have a hood to pull up over one's cap in bad weather, and should have a large pocket in front to put one's mitts in when not in use. The moccasins should be made large, so as on no account to cramp the foot. They are only intended to be worn during extreme cold.

The daily allowance of provisions for those engaged in sledge-traveling is as follows: For each man, 1 lb. pemmican, $\frac{1}{4}$ lb. boiled pork, 14 ozs. biscuit, 2 ozs. preserved potatoes, $1\frac{1}{2}$ oz. prepared chocolate, $\frac{1}{2}$ oz. tea and sugar, 1 oz. concentrated rum; 4 ozs. fuel being used daily for each individual; also a weekly allowance per man of $1\frac{3}{4}$ oz. salt, $\frac{1}{4}$ oz. pepper, 1 oz. curry or onion powder, and 3 ozs. tobacco, making a weekly allowance per man of 19 lbs. 3 ozs., which is a very liberal one, and well adapted to long journeys in the most severe weather. In fact, at first starting, the men are not able to consume the full amount allowed of pemmican, but after a few days' hard work and exposure this little difficulty is soon overcome. Fuel may consist of different materials. There is the camphorated spirits of wine, whose great charm consists in its being camphorated, and therefore cannot well be tampered with by the men. Methyllated spirits of wine has also been much used, and is cheaper than pure alcohol. Sir Leopold McClintock, in the Fox, used crude cocoa-nut oil, which he found very useful and very cheap. Its advantages over tallow are: 1. That it cooks much more rapidly; 2. It makes very little smoke (an important item); and, 3. There is nothing disagreeable in smell or taste about it.

Great care must be taken in the stowage of provisions, and, in fact, in all that relates to the equipment of a sledge, as it is most important that the greatest economy in the matter of weights should be arrived at. The officer conducting the sledge-party is, of course, responsible that the necessary instruments are taken that will be required for fixing astronomically different positions, and for delineating the coast-line. Every thing being in readiness for a start, the sledges, which we will say are six in number, with their distinguishing flags (to each of which there is usually a history attached) fluttering bravely in the breeze, are drawn up outside the ship, the men, cheerful and joyous, with their drag-ropes in hand, the officers with their rifles slung across their shoulders, receiving their parting instructions, all

hopefully confident of success, and all eager to accomplish all that man can do. It is an animated scene, all are merry and glad, with the exception, perhaps, of those few that must of necessity remain behind, to look after the ship. The crews of each sledge consist of an officer and seven men, and by a system which has already been adopted with great success on previous occasions, one sledge could be advanced to at least fifty days' journey from the ship, or more correctly twenty-five days out, and depots placed for the return-journey. This is effected in the following manner: After traveling in company for a week, No. 6 sledge will complete the remainder to their full amount of fifty days' provisions and return, the remaining five proceeding on their way. When six more days have elapsed, No. 5 sledge will return to the ship, having filled up the remaining four to what they originally started with, and so on until No. 1 sledge is left to proceed by itself. In the mean time the sledges that have returned will immediately reprovision, and will lay out depots for the use of, and meet the returning sledges, ready to render any assistance they may require.

As an outline of the daily routine observed by sledge-parties during their arduous employment may be of interest, we will briefly refer to it. As it may be advisable some time to travel during the night, for the same reason that Parry did, we will not name any hour, but merely the time of rising and going to bed. We will begin with the commencement of the day's work. The first thing to be done is to awaken the cook of the day, who at once sets to work to prepare breakfast. The time occupied in preparing this meal is usually about an hour from the time he is called. When nearly ready, he brushes off the condensation that has taken place during the night, from off the coverlet, and from the inside of the tent, and then arouses the whole party. If the weather is very severe they sit up for breakfast in their bags, but if not, they roll them up, as also the tent-robes, put on their moccasins, etc., ready for the march, and then, sitting on their bags and knapsacks, discuss their morning meal. The sleeping-bag is, as its name designates, a large bag made of the Hudson's Bay three-point blanket or of duffle. It is about seven feet long, and is best fitted with the opening in the side instead of at the top, as in this way it is more convenient to get into and out of, and the more readily enables a man to sit up and keep it over his head while eating his meals or while writing.

When breakfast is finished, the biscuit and pork to be used for lunch should be measured out, and placed in the luncheon haversack; dilute the day's allowance of rum, and any water that may be remaining put into the men's water-bottles. Issue to the cook the day's allowance of stearine, and put the requisite amount of spirits of wine into the lamp. The cook trims both lamps, and is then relieved by the cook whose turn it is for the next twenty-four hours. In large parties

it would be as well to have a cook's mate in addition, who would succeed the cook when his term of office had expired, a fresh hand being installed in the capacity of cook's mate. The whole of the tent-furniture must be well brushed, so as to get rid of any snow-drift, or condensation, and the tent itself should be well shaken before being stowed on the sledge, which is then packed, and the march begun. The officer takes his observations for time or variation, also the bearings of land, temperature, etc., at a regular time before starting.

After marching for about six hours, halt for twenty minutes for lunch. The spirit-lamp is used to dissolve snow, and the grog, pork, and biscuit, are issued. If the wind is fresh, turn the sledge at right angles to it, and with sledge-sail to form a lee, sit-down. If very severe weather, pitch the tent, and sit inside without any tent-gear, or stop only five minutes for grog and biscuit. When halted for the night, and the tent is pitched, one man, after brushing himself well, goes inside, and receives and places all the gear, robes, knapsacks, sleeping-bags, etc. The cook prepares supper without delay. When all the work is completed the men take off and hang up their moccasins or boots and blanket-wrappers, either upon the tent-ropes outside, or on the tent-line inside, according to the weather, brush themselves well, divest themselves of their overalls, and take up their respective places in the tent, the officer always at the head of the tent, the cook and cook's mate nearest the entrance, so that their rising does not disturb the rest. Supper consists of warm pemmican, the quantity in each pannikin always being carefully equalized before being served out, then a drink of tea or water, when pipes are lighted and the party compose themselves for their night's rest; songs and yarns, if not too cold and exhausted, bringing the day's proceedings to a close. The officer, as a rule, takes his observations while supper is being prepared, and before lying down winds up his chronometer and writes his journal. A very good rule is to give directions, for precaution's sake, that the tent-robe is never to be spread until the question has been asked, "Has the chronometer been wound up?" Before retiring, the cook sees every thing in readiness for the morrow's breakfast; the captain of the sledge serves out the breakfast allowance to him, and sees every thing connected with the sledge secure and safe.

The tent is made of light, close, unbleached duck, twelve square feet weighing a pound, lined with brown holland across the head, or end opposite the door, up to a height of three feet, and along the sides to a height of two feet. It is spread by means of tent-poles, two (crossed) at each end, and set up with tent-ropes or guys. A window, six inches square, is fitted at the upper end with a flap to trice up or haul down. There should also be a pocket at this end for the use of the officer, in which instruments, etc., might be placed. A cook's pocket at the opposite or door end of the tent is also convenient. In *very* severe weather the cooking has sometimes to be per-

formed inside the doorway; it is, however, very objectionable, and should not be practised more than is absolutely necessary, as the steam condensing covers every thing near it with fine particles of frozen vapor, and the soot from the stearine-lamp blackens every thing. The furniture for a tent consists first of a water-proof floor-cloth, made of a light description of mackintosh; this should be used with care, and only over snow. The coverlet should be made of the Hudson's Bay three-point blanket or thick duffle, its upper side covered with glazed brown holland. Three stops should be sewn on one end of this coverlet, for tying it when rolled up, and when in use for tying it to the lower robe at the upper end or head of the tent. The knapsack forms the pillow.

The canvas floor-cloth, though not absolutely indispensable, is, however, very useful. It is made of very light unbleached duck, and is also used as the sledge-sail, which is only set when the wind is abaft the beam. It should be laid down over the water-proof floor-cloth, when the men are taking off their boots and taking their suppers. In severe weather, when the breath condenses in the tent and falls in minute frozen particles, the canvas floor-cloth is useful to spread "over all" after the men have laid down, as it catches all this fine snow, which would otherwise penetrate into the coverlet, where it would thaw by the heat from the men's bodies, and be frozen into them again when exposed to the air. "So rapidly," says Sir Leopold McClintock, "does frost accumulate, that in eighteen days of traveling during the month of October I have known the coverlet and the lower robe to become more than double their original weight."

The lower robe or blanket should be of the same material as the coverlet, namely, three-point Hudson's Bay blanket or thick duffle. It should have a covering of brown holland on its underneath side, having stops on its upper side to tie to similar stops on the coverlet when spread for the night: probable weight of the lower robe about seventeen pounds. This robe has sometimes been of fur, but it has its disadvantages, as in the first place it is more absorbent; a skin will when wet emit a disagreeable smell; the hairs come out, and they shrink very much; they are also more stiff and unmanageable when frozen. The above-mentioned woolen materials are on the whole preferable, as they are quite as warm as fur, when covered with the brown holland, in addition to which evaporation from the body will generally make its way through woolens, and escape into the air, but in the fur robe is arrested and condenses in it. The coverlet, lower robe, and sleeping-bag, answer well when the temperature is no lower than $-30°$, but should it fall lower, an additional coverlet should be supplied, as well as a small blanket bag to put into the sleeping-bag to keep the feet warm. Should the temperature continue to fall, snow huts should be used, they being very much better and warmer than tents. A party of four men can, after a little practice, hut themselves

in about half an hour; one man cuts the blocks, another builds, and the other two carry the blocks and fill up chinks, etc.

Building a hut with a large party, however, is a different matter, the difficulty in constructing the dome greatly increasing as its diameter is enlarged. It then becomes a question whether it would not be more advisable to build two huts, and to divide the tent-robes, etc., between them, or to build four walls inclosing a space of about six and a half feet wide, and long enough to accommodate the whole party (fourteen inches being the allotted space of each man). The tent is then used as a roof, by being laid over the walls, and snow thrown on it to prevent the wind blowing it off. The walls should incline inward slightly, and be about five feet high, and the floor excavated to a foot or so to give additional height inside. The advantages a snow hut has over a tent-roofed house is, that should the temperature become high, the moisture overhead runs down the walls in the former, whereas in the latter it drips, and makes the tent so wet that when it freezes again it is almost impossible to spread it. The snow hut which Englishmen should construct (that is, without the aid of the Esquimaux) is made of slabs of caked snow about two feet long, one wide, and six inches thick. The site (a circle) is first marked out on the snow, and beginning with a very narrow slab, inclining slightly inward, the building is commenced and continued spirally, until at a height of about five feet, when a single rounded slab is cut, closing up the centre of the dome. The entrance is as low as possible, and is cut the last thing by the man inside. When the temperature is low it will be found preferable to encamp on snow rather than on land, and still warmer upon ice when there is water underneath, which will materially add to the warmth and comfort of the encampment.

While dragging the sledges it is very necessary to keep continually changing the leading men on the drag-ropes, as on them rests the severe task of exerting their eyes in order to pick their road, and they are therefore more subject to snow-blindness than the others. The officer, when not engaged in dragging the sledge, should be very particular in selecting a good and easy line of country; this is of the utmost importance.

We will now suppose that the season for sledge-traveling has passed, the sun no longer sinks below the horizon, the object for which the sledge-parties have been striving has been gained, and they have all returned to their ship, which they left three months before frozen up in the solitude of their winter quarters. Some, which have returned early, after taking out depots for the extended parties, have since been actively engaged on regularly-organized shooting-excursions. But all are back by July. They return to a busy scene. Active preparations are being made to get the ship ready for sea. The housing is taken down and stowed away below, and it is to be hoped will not again be seen, as rumor whispers they are homeward bound;

spars are swayed up and sails bent, and the ship is again "all a taunto," and all are anxious once more to feel the long roll of the ocean. The open water is seen to the southward from the crow's-nest, but it is some distance off, and the ship is held fast in the wintry grasp of the ice. The month of June has come and gone, July is nearly at an end; if they are not shortly released, they will perhaps be doomed to spend another winter in that inhospitable and inclement region. During the preceding months those on board have not been idle, as a long line of ashes, sand, and rubbish of all descriptions, thinly sprinkled from the ship's bows in a long straight line to the southward, will testify. This has been done with the object of penetrating and rotting the ice, the dark color attracting the heat of the sun, so as to make a passage for the ship to pass through. This device has failed, and others must be resorted to to effect their liberation.

Blasting has been determined upon. Charges of three pounds, five pounds, and ten pounds of ordinary gunpowder will be prepared for use, in tin canisters, with Bickford's fuse. If, however, the new explosive "cotton gunpowder" should be the substance selected to carry out this object, a small charge of about two pounds is prepared, primed with its detonator, to which is attached a short length of Bickford's fuse. Operations are commenced from the open water and carried on toward the ship. A hole is made in the ice by means of a drill some distance from its edge, and the charge is lowered down through this until it reaches the water and is placed immediately under the ice. The fuse is ignited, a sharp explosion takes place, and the ice is shattered and rent in all directions. Men in boats, and others armed with boat-hooks and long poles, at once assail the fragments, removing them from the channel into the open water. These operations are repeated until a clear channel has been made, through which the ship is able to steam and thus effect her escape. The advantages which the "cotton gunpowder" has over ordinary black gunpowder are numerous. It is a much more powerful explosive, its proportionate strength to common powder being as eight to one, but its great merit is said to consist in its perfect safety. If put into the fire it will burn quietly, without any explosion, nor will it explode on concussion.

The practice of ice-blasting is not a new invention, and had been much resorted to by the various search expeditions. Their plan was simply to lower a glass bottle, or preserved meat tin, containing from two to four pounds of ordinary gunpowder below the ice, and explode it. The results were most satisfactory. Lieutenant Mecham tells us that during Captain Austin's expedition, in 1851, a blasting-party was employed for twelve days in detaching a floe from the eastern shore of Griffith Island. With 216 pounds of powder they cleared away a space 20,000 yards in length, and averaging 400 yards in breadth; this ice varied from three to five feet in thickness. The estimated weight of the ice removed was about 216,168 tons. The heaviest

charge used on this occasion was sixteen pounds, lowered ten feet below five-feet ice; its effect was the breaking up of a space of 400 yards square, besides splitting the ice in several directions. The last charge would be equivalent to two pounds of "cotton gunpowder," but the results with the latter explosive would, in all probability, be far more effective.

The work of an exploring expedition in the arctic regions for the period of twelve months has now been detailed. No unforeseen accident, no detention in the ice, in fact no casualty of any description has been taken into consideration, but every thing has progressed under the most exceptionally favorable circumstances. That the same will be the case with the Arctic Expedition of 1875 is too much to expect, but that it will be successful in exploring a large area of unknown land may be confidently hoped and anticipated.—*Geographical Magazine.*

## DISTRIBUTION OF ATMOSPHERIC MOISTURE.

ALL over the earth, the more largely where its beams reach the surface with the least diminution of heat, the sun is continually engaged in evaporating moisture from all exposed surfaces of water; this remains suspended in the atmosphere, and is carried about by the winds in the form of impalpable vapor or of clouds, till the point of saturation is reached, and the moisture falls again to the earth's surface in the form of rain, or snow, or hail. Air becomes lighter, and consequently expands and ascends, when it grows hotter, and becomes heavier and falls with cold. The hotter it is the more moisture it is able to hold in solution. Between the equator and the poles there is a difference of 80° of average annual temperature. In the torrid zone the light, warm, vapor-laden air is ascending continually to the upper regions of the atmosphere, and there flowing outward north and south toward the poles, and the cold, heavy air from the polar regions comes rushing along the surface to fill its place. As the seasons change, the line of the greatest heat in the world gradually moves its position. At the equinoxes of spring and autumn it runs along the actual equator, or near it. In winter it lies south of the earth's equator, about midway between the equator and tropic of Capricorn. Not more than half as much of the tropic of Capricorn as of the tropic of Cancer runs over land, and this makes a material difference, because the more sea the more the intense heat is deadened and absorbed. In summer the great continental area traversed by the tropic of Cancer, a long line of which is removed from the ameliorating influence of the sea, becomes excessively heated, and from the great African Sahara, through Nubia and Arabia to the north of India, runs a tract of intense heat, in which the July average in the shade rises to 90°.

Zone of Periodic Winds and Rains.—It is to this changing line of the greatest heat that the main currents of wind are directed. Within a zone extending for about 30° on each side of the equator the winds blow with great regularity. When they leave the polar regions the tendency of the surface-currents is due north and south, but in their course they become deflected longitudinally in consequence of the earth's motion, and reach the line of greatest heat as northeast and southeast currents. The tropic of Capricorn has its air rarefied by heat in our winter, and this produces within the torrid zone what is called the northeast trade-wind or monsoon. The tropic of Cancer has its air still more rarefied by heat in our summer, and this produces the south monsoon. Through these causes this central belt of the world has its winds and rains perfectly steady and regular, and within it there falls the greatest quantity of rain which there is in any part of the world. The rainy season begins some time before the sun reaches the zenith of a place, and continues for some time afterward. In a belt near the equator there are two rainy seasons, the main one, which lasts three or four months, beginning when the sun, in its progress to a vertical position, has crossed the equator, and a shorter one, which lasts four or six weeks, when the sun is coming again from the tropic to the equator. Nearer the two tropics the countries have only one rainy season, which begins when the sun approaches the tropic, and one dry season, the year being divided between the two. The rain pours down in torrents in a way of which we can form no notion from our experience in temperate countries. Our London rainfall is 2 inches a month, but in the tropics an inch a day is not an uncommon average for the whole rainy season. On the banks of the Rio Negro Humboldt collected as an ordinary rain $1\frac{3}{4}$ inch in five hours. In Cayenne Admiral Roussin collected, between the 1st and 24th of February, $12\frac{1}{2}$ feet, and in one night, between 8 P. M. and 9 A. M., measured $10\frac{1}{4}$ inches. In the Himalayas of Khasia as much as 600 inches are said to fall in a single year. The rain, however, does not commonly pour down without intermission night and day, and day after day, as is sometimes the case in the English lake country. The ordinary succession of atmospheric phenomena is as follows: The sun rises in a cloudless sky. Toward noon some faint clouds appear on the horizon, which increase rapidly in density and extent, and are soon followed by thunder and violent gusts of wind, accompanied by heavy rains. Toward evening the rain abates, the clouds disappear, the sun sets in a serene sky, and during the night no rain falls. The annual quantity of rain which falls upon any particular place depends greatly upon local circumstances, just as it does in the temperate zones, and is greatest where hill-ridges are placed so as to catch the clouds, and smallest in tracts that lie to landward of such ridges. To take our illustrations from India, where the south monsoon blows laden with the copious vapors raised by the equatorial

sun from the broad expanse of the Indian Ocean, we find that in the eastern Himalayas the rainfall varies from 200 to 600 inches a year, and that at Mahabaleshwar, where the clouds drift against the high ridge that lines the west side of the peninsula, it is 248 inches, but that at Courtallum it is only 40 inches, at Bangalore 35 inches, at Cape Comorin 30 inches, and at Bellary in Mysore 22 inches, which is as low as in any part of England.

Zone of Periodic Winds without Rain.—Outside the zone of periodic winds and rains comes a double belt, one girdling the world in the northern, and the other in the southern hemisphere, the breadth and area of which are greatly modified by local circumstances, within which no rain ever falls. These belts are estimated to include altogether an area of 5,000,000 square miles, but it is impossible to make any calculation that is at all precise, because round the tracts that are entirely rainless are regions in which rain falls but rarely, which again pass gradually into the two rainy zones, through countries like Southern Palestine and the Gangetic plain, which, though usually rainy, are liable at intervals to years of drought. These belts of rainless land near the tropics contain some of the most hopelessly dreary country which the world can show. Beginning with the west of the old continent, we have along the tropic of Cancer in Africa the Sahara or great desert, on the southern border of which the rains cease at 16° north latitude, and begin again on the north at 28°. Passing farther east, the southern rains cease in the countries on the banks of the Nile between 18° and 19°, and the northern begin between 27° and 28°. Passing into Asia, there is a great rainless tract in Arabia of which we do not know the exact bounds, and it reaches through Beloochistan over into the delta of the Indus, where it does not cover more than 4° of latitude. From this point the rainless zone turns to the northeast and extends to 30° north latitude. Crossing the great Himalayan chain it includes the high table-land of Thibet, but does not appear to reach into the Chinese Empire. In South Africa there is a sandy, desert, rainless tract on the north of the Orange River, between 24° and 28° south latitude, and a great part of the interior of Australia seems to be nearly or quite rainless. In North America the rainless belt includes the Californian peninsula, and extends round the northern end of the Sierra Madre chain past Chihuahua and Monterey to the shores of the Gulf of Mexico between latitudes 24° and 26°. In South America it includes between latitudes 23° and 27° the northern province of Chili, and, through an extensive low tract in the interior of the continent belonging to the territory of the Argentine Confederation, rain is very unfrequent and small in quantity.

Zone of Variable Winds and Rains.—From about latitude 30° on each side of the equator to the poles extends a region of ever-changing and variable winds, and of rain that is irregularly distributed throughout the whole year. Sometimes in these middle lati-

tudes, in Britain, for instance, we fall within the sway of the south-rushing polar current deflected to the east by the earth's rotation, and sometimes within that of the north-rushing current from the equator, deflected to the west by the rotation which it shared with the earth at the zone from which it started. In Britain this southwest wind comes to us laden with vapor from the great mass of the Atlantic, and makes Ireland and our western shores unusually damp and rainy. The relative temperatures of sea and land in the temperate zones are continually changing with the seasons. In summer and autumn the Atlantic is colder than the European Continent, and this has a tendency to produce a west current at the surface. In winter and spring the Atlantic is warmer than the continent, and this has a tendency to produce an east wind. Sometimes one of these varying tendencies gains the predominance and sometimes another, and the result is constant and often rapid change and variety. The heat and moisture which the wind brings with it depend entirely upon where it comes from, and what it has passed in its way. A west wind blows to us from the Atlantic, and usually brings rain; an east wind brings up the fog of the German Ocean; and in winter and spring the prevalent northeaster brings the cold and often the snow of Russia and Norway. At the sea-side, unless it be overpowered by a general current, there is a breeze from off the sea during the day, and a breeze from off the land during the night. The quantity of rain that falls in this zone at different points is extremely variable, and depends upon the position of a place with regard to mountain-masses and the seas from which the vapors come. In England the rainfall is greatest on the west side of the island, and smallest on the east. The difference within a short distance is sometimes very striking. There are 140 inches a year at Borrowdale, in the lake district, and not more than 20 inches at Shields and Sunderland, which are directly opposite on the east coast. But the habitual humidity of the atmosphere often varies but little between places the rainfall of which is very different. The number of days upon which more or less rain falls, varies in England from 100 to 300, but in the Mediterranean region the number of days is fewer, the quantity is smaller, and there is an almost regular period of entirely dry weather in summer. Taking the north temperate zone as a whole, there is, as a rule, least rain in places away from hills in the interior of continents, and most in insular and mountainous situations.—*Gardener's Chronicle.*

# CORRESPONDENCE.

## SCIENCE AND THE BOOK OF GENESIS.

*To the Editor of the Popular Science Monthly:*

I HAVE been an attentive reader of THE POPULAR SCIENCE MONTHLY for over two years, and in that time not one article, editorial, or note of correspondence, has escaped my notice. Also, I have been deeply interested from the first in all the advanced positions of the MONTHLY, and have noted its strictures on the narrow intolerance and ignorance of the clergy, and the many hints that they should enlarge the field of their observation and knowledge; and I am convinced that many of these hints are well-timed. But, then, ought not men of science also to be more liberal and better acquainted with biblical knowledge? The theologian observes in the writings of men of science the same narrowness and ignorance of the Bible that the scientist sees in the writings of theologians concerning his particular line of study and investigation.

In No. XXXVII. of THE POPULAR SCIENCE MONTHLY, the editor says, in his notice of Dean Stanley's sermon on the death of Sir Charles Lyell: "Dean Stanley is far from being alone in his views; they are shared by many other eminent clergymen who recognize that the Mosaic account of creation is without authority." But, does Dean Stanley indeed "recognize that the Mosaic account of creation is without authority?" Be that as it may, ought not any man to lose the respect of his fellowmen who will consent to remain a clergyman, and yet reject the authority of the Bible?

Certainly no particular account of creation was intended by the author of the Book of Genesis—nothing more than a brief outline, and he gives no intimation as to the time when this world began to be. Nor is there any reason why the six days of creation should not be regarded as so many general periods, without any limitation as to duration. But, if you will carefully notice the statements of Moses, you will find some things hard for the scientist to dispose of, if the account of creation is without authority. Moses says: "In the beginning the earth was without form and void." Does not the scientist say substantially the same thing?

Then take the different stages in the progress of the world, as stated by Moses, and especially as to the appearance of life; do they not agree perfectly with the revelations of science? Moses says the first life was vegetable—grass, herb, tree. Next came a low form of aquatic animal life—"the moving creature that hath life"—developing into fishes and fowls of the air. Then land-animals, and, lastly, man appeared on the earth. Now, what says modern science of this arrangement? Does it not fully sustain this Mosaic account of creation? Even the modern doctrine of evolution—Darwinism, if you please—is as nearly taught in the first chapter of Genesis as in the revelations of modern science; and spontaneous generation seems to appear on the very face of the statements of Moses as therein recorded. Read verses 20 and 24: "And God said, Let the *waters bring forth abundantly*," etc., "And God said, Let the *earth bring forth*," etc. And as for man, if God saw fit to straighten up a monkey and endow him with human reason, whether that took the Almighty one hour or a thousand years, who need object? It is certain that it can be proved neither by the Bible nor modern science, either that God did or did not make man in that way.

But here comes the question as to the authority of the Mosaic account of creation: How was the author of that account able to state in so brief a space the main points in the earth's development, just as they are now known by the revelations of science, when he wrote at least three thousand years before the sciences which have now brought these things to light were born? Was Moses a profound scientist?

or did he write under the influence of divine inspiration?

Rev. J. C. Mahin.

Peru, Indiana, *June* 21, 1875.

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THE MECHANICAL POWER OF LIGHTNING.

*To the Editor of the Popular Science Monthly:*

In the afternoon of June 26, 1874, a thunder-storm passed over the town of Cummington, Hampshire County, Massachusetts, during which an exhibition of the mechanical power of lightning was displayed, which I believe is extremely rare, at least in this latitude.

A sugar-maple tree (*Acer saccharinum*), thirteen feet in circumference four feet from the ground, was struck, and split in several places, apparently throughout its diameter, from the ground to a height varying from twelve to twenty feet. On reaching the earth, the main portion of the shaft passed to a piece of wet ground several rods distant, in its way ploughing a furrow from one to over three feet in depth, tearing seven trees, the largest six inches in diameter, from the ground, and throwing them several feet from their former places. A rock containing thirty-six cubic feet was torn from its bed, and rests on the surface, three feet from its original position. In its course it passed under another maple, two feet in diameter. The tree was not thrown down, but the earth was thrown up from beneath its roots, in places, to the depth of three feet. This tree stood about sixty feet from the one struck. It then passed thirty or forty feet farther, through earth so wet in some places that the trench made by it filled with water. After making a cut eight feet wide at the surface, and three feet deep through a knoll, it divided, and, after passing a short distance farther, struck at three points a half-inch lead water-pipe, running at right angles with its centre, filled with water at the time, and covered with about two feet of wet earth, which was thrown out, and the pipe destroyed for a distance of 200 feet. No trace of the pipe could be found in many places, excepting scattered gray oxide of lead. In its way from the tree to the pipe, large masses of mica-slate rock were shattered, and one observer saw large stones which were thrown above the top of the surrounding trees.

Nearly the whole distance traversed by the lightning was woodland, and the soil was firmly bound together by interlacing roots; many of these, large enough to resist the power of the strongest yoke of oxen, were snapped like pipe-stems, the fracture being almost as smooth as if cut with a saw. Lighter portions of the electricity radiated in various directions from the tree, turning up the earth like a plough, for a distance of from 40 to 100 feet. The tree was struck while the rain-cloud was at least two or three miles distant. Many people were out, making preparation for the coming shower at the time, and the bolt was seen by several persons as it darted from the coming cloud. I visited the place nearly a year after the event, but all that I have described is yet visible. I can only account for this tremendous force by supposing that the water in the soil, converted instantly to steam, produced these results.

Dewey A. Cobb.

Providence, R. I., *June*, 1875.

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# EDITOR'S TABLE.

## *RELATIVITY OF TRUTH.*

Among the higher influences of science to be realized in the future, will be its inculcation of more correct views concerning the relation of the human mind to truth. The effect of partisanship in politics and theology—the two great schools in which people are chiefly educated—is to establish the idea that truth is something absolute, that can be got once for all, and then can be comfortably held and professed forever afterward. There are only truth and its opposite error sharply divided off to choose from; and a "yes" or "no" is demanded for all propositions. In some things this is no doubt true; there is only one side to the multiplication-table.

But, in extensive divisions of thought, truth is only a relative thing; of inestimable value for its time, and most of all valuable as a means of getting away from it and attaining more perfect truth. Logic is the art or science of arriving at truth by ratiocination; but science is the field where logic is put to practical application and subjected to the most rigorous tests. The human mind if left to logic alone may go wild in any direction; science holds it steadily to the observed order of Nature as the standard by which it is to be tried. The whole circle of the sciences bears witness to the correctness of scientific thinking; and the history of every science abounds in proofs of the relativity of truth. Certain parts of elementary facts may remain constant, but even the interpretations of these, true only for their time, are changed, age after age. The science of chemistry affords an admirable exemplification of this view.

There was vague and indefinite truth even in the chimeras of the alchemists, mixed indeed with an enormous amount of gross error and preposterous speculation as seen from subsequent points of view; but there was sufficient of verity and correspondence to reality in those mystical times to guide men to important discoveries. The alchemists found out a great number of new and valuable things. They worked under delusions, but these were far from being destitute of plausibility; and were in fact in no small measure consistent and rational. Experimental knowledge at any rate grew in extent, and somewhat in coherency, until the absurdities of the epoch fell away and a definite and rational chemical system ensued.

This was the epoch of *Phlogiston*, which was held to be a kind of subtile matter or energetic essence, present in all combustible bodies and absent in all incombustible bodies, and which caused combustion-changes in its escape. It was a theory of the nature and cause of fire; and, as heat is implicated in nearly all chemical changes, it was a crude theory of chemical action. It served the most important uses. It was a principle of connection and association, and explication, which stimulated investigation, guided inquiry, and enlarged the domain of actual knowledge. A chemical belief that the discoverer of oxygen, Dr. Priestley, held to the day of his death, could certainly not have been an absurdity. Prof. Cooke has the following excellent remarks on this early theory: "That it was not absurd a single consideration will show. Translate the word *phlogiston*, *energy*, and in Stahl's work on chemistry and physics, of 1731, put *energy* where he wrote *phlogiston*, and you will find there the germs of our great modern doctrine of conservation of energy—one of the noblest products of human thought. It was not a mere fanciful speculation which ruled the scientific thought of Europe for a century and a half. It was a really grand generalization; but the generalization was given to the world clothed in such a material garb that it has required two centuries to unwrap the truth." Nevertheless there was invaluable truth in it, but truth obscured, imperfect, and in relation to the time.

The phlogistic doctrine broke down as the facts accumulated and outgrew it; and chemical science passed into a new phase. That which had long helped at length became an obstruction, and, with the abandonment of the entity, chemical effects began to be referred to inherent attractions among different kinds of matter. But the facts must still be interpreted by principles or theories, and, at the epoch of Lavoisier, affinity, or the energy of chemical change, was viewed simply as a coupling force. Combination and decomposition were supposed to take place directly among bodies in pairs; elements uniting with elements to form binary compounds, and these uniting again by twos to form

double binary or ternary compounds, and when these were made to act on each other the reaction was represented as a double decomposition. This was known as the dual theory of chemistry, and it organized and explained the facts of the science in the most beautiful manner. Electro-chemistry lent it powerful aid, as compounds were resolved into pairs by galvanic decomposition, and their elements were supposed to be in opposite electrical states and to be united by polar attractions. The atomic theory gave a basis of philosophy to the doctrine, and the admirable nomenclature which was adapted to it gave it wide currency and acceptance. Under this chemical system the science grew and flourished for more than half a century, spread out into branches, and became the guide in medicine, mining, agriculture, and numberless arts and manufactures. Yet this system, too, was true for its time; only true in relation to the facts known, and is now doomed to the fate of phlogiston. As it grew out of a preceding stage upon which it was a great improvement, so it has led to a subsequent and higher stage of knowledge, to which it must in turn give way. Its facts live on; its partial truths survive and are expanded into new forms, and a system of doctrine has arisen so contrasted with the dual theory and so advanced beyond it that it is now characterized as the "new chemistry" in contradistinction to the old which it has superseded. We are now entering upon the new chemical epoch in which ideas that have long simmered in the brains of chemists, and were long contested, have emerged into distinctness and are passing into predominance. The simple splitting and pairing theory of chemical change has failed, and we are becoming familiar with the conception of unitary structure, molecular types, and transformations by substitution and replacement that leave the construction and character of chemical compounds unaltered. The dualist appealed to analysis, and asked only what are the constituents and what their proportions in chemical substances. The apostles of the new chemistry point to the failures of analysis, and aver that it is not so much what a compound is made of, as how its elements are arranged, that is the present concern of inquiry. And chemistry was probably never so active as now under guidance of the new theories, and never before answered so well to that highest test of science, the prevision and prediction of chemical results. There is no escape from the new chemistry. It absorbs the verities of the past and it is the highest truth arrived at by centuries of thought and labor. But it is not a finality. Its truth, though priceless, is imperfect, and is no doubt destined to still further and higher development. Historically regarded, the science of chemistry is a striking exemplification of the laws of mental evolution, as the doctrine of evolution is the grandest illustration of the relativity of truth.

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An interesting illustration of the striking changes of view that have taken place in modern chemistry is furnished by the reversal of scientific rank assigned to those prime elements of Nature, oxygen and hydrogen gases. Oxygen was long enthroned both from its enormous distribution in earth, sea, and air, and its active participation in the great changes of matter, combustion, respiration, decay, all of which were generalized as different forms and grades of *oxidation*. It was supposed to be the acidifying principle in Nature, and was early taken as a standard in chemical scales. Hydrogen was also known as a widely-diffused and important element, but of far inferior import to oxygen, and received its name from the fact that it generates water by union with oxygen. But, as more was known about it, it was found to be deeply im-

plicated in the universal transformations of matter. It turned out that hydrogen not oxygen is the great acidifying principle, and not only so, but it is the base-producing principle, while the old and antagonizing classes of acids and bases disappeared as separate groups and were merged in one great division of hydrates. Hydrogen, moreover, by its remarkable properties and position has become the unit and standard of the modern chemical system, and, though less abundant upon earth than oxygen, it is the grand element of the sun, has been detected in the remotest stellar luminaries, in the mysterious nebulæ, and blazed out in a mighty conflagration of one of the most distant stars. Such is the part played by that form of matter which is the most attenuated, ethereal, and "nearest to nothing," of any we know.

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## LITERARY NOTICES.

The Principles of Sociology. By Herbert Spencer. A Quarterly Serial. Part III. D. Appleton & Co. Price, $2.00 a year.

It is an essential part of Mr. Spencer's method of treating sociological science to trace the genesis of the fundamental ideas which have become embodied in social institutions. The installment of his work now before us is devoted to the origin and development of religious ideas. These have been powerful in all ages, in all places, and in all grades of society, in influencing human conduct, and in determining the constitution of the social state. In this country religion is largely differentiated from government; but it remains at the basis of extensive and important institutions. In European nations, and in most countries in fact all over the world, religious establishments are still part of the state organization and potent factors in determining the structure of society. An element of the social state, so universal and pertaining to humanity itself, is certainly a fit subject for scientific elucidation. For, although it is claimed in special cases that religious ideas are not of natural but of supernatural origin, and therefore not amenable to the scientific method of investigation, yet those who entertain this view always limit it to a particular case. The believers in the supernatural origin of religious conceptions generally restrict their view to the one religion which they hold to be true. But, although the implication is that all other religions are false, they still remain to be accounted for, so that, admitting the supernatural character and origin of a single system of faith, there yet remain hundreds of other systems of all complexions and gradations which are the legitimate subjects of study from the scientific point of view. A Christian may hold his system to be preternaturally given, and its origin to be not open to scientific scrutiny or criticism; but he cannot object to the employment of science in tracing out the development of religious notions among heathen and savages. There is, therefore, plenty of legitimate room to carry on the inquiry.

In this number of his work Mr. Spencer devotes himself to tracing the origin and growth of religious ideas, that in their various forms may be regarded as universal. His aim is to show that they are natural and necessary outgrowths of the intercourse with Nature of the human mind before it has learned any thing of the true order of Nature. In his successive chapters he treats of "The Ideas of Death and Resurrection," "The Ideas of Souls, Ghosts, Spirits, Demons, etc.," "The Ideas of another Life," "The Ideas of another World," "The Ideas of Supernatural Agents." The argument, as is usual with Mr. Spencer, is able, the analysis clear, and the presentation forcible. The work is full of fresh and interesting information regarding the mental states and habits of the lower races of mankind, and the accompanying psychological discussion gives an impressive interest to the facts.

Transits of Venus. A Popular Account of Past and Coming Transits from the first observed by Horrocks, 1639, to the Transits of 2012. By Richard A. Proctor. 232 pp., 12mo. New York: E. Worthington & Co.

This last book from Mr. Proctor's pen is written in his usual charming style, and, as the author says, is intended to be partly historical and partly explanatory. The

book opens with an account of the transits of the seventeenth century, when, as a consequence of the establishment of the Copernican theory of the solar system, astronomers perceived that the inferior planets, Mercury and Venus, must from time to time appear to cross the face of the sun. Kepler calculated and announced, in 1627, that in the year 1631 both Mercury and Venus would pass over the sun's face—Mercury on November 7th, and Venus on December 6th; and that in 1761 Venus would again pass across the face of the sun. As the first occasion on which the transit of an inferior planet was ever witnessed, the transit of Mercury in 1631 has an interest resembling that which attaches to the first observation of a transit of Venus, eight years later, the one contemporaneous with Mercury not having been observed, as it took place in the night-time; and, as to this one which took place eight years later, Kepler had calculated that, while in inferior conjunction December 4, 1639, Venus, though near the sun, would pass below its disk, and there would be no transit, which calculation happily was found to be a miscalculation, and therefore a transit would really occur. The first observation of a planet's transit, that of Mercury, was made by Gassendi, of Paris. Through a small aperture in a shutter the solar light was admitted into a darkened room, and an image of the sun, some nine or ten inches in diameter, was formed upon a white screen. A carefully divided circle was traced upon this screen, and the whole was so arranged that the image of the sun could be made to coincide exactly with the circle. As he had no trustworthy clock with which to ascertain exactly the moment of ingress, which he was anxious to do, he determined that the altitude of the sun should be carefully estimated during the progress of the transit. For this he needed an assistant, whom he placed, with a large quadrant, in a room above him, instructing him to observe the height of the sun as soon as he heard Gassendi stamp upon the floor of the room beneath. With these preparations Gassendi began to watch for the transit *two days* before its appointed time. To make a long story short, by the evening of November 7, 1831, the *first transit* had been observed, and in the manner here described. The first observed transit of Venus (to which planet Mr. Proctor gives his whole attention from this point) followed that of Mercury, and was calculated and observed by Horrocks, a young minister of Hoole, in Lancashire, who was a prodigy for his skill in astronomy. He was but twenty years old when he calculated this transit, and died two years afterward. He possessed a telescope, "the recent and admirable invention," which he used in the observation. The transit came on Sunday. He had watched two days, and Sunday until the hour for divine service. Returning from this at fifteen minutes past three in the afternoon, he found Venus just entered on the sun. Sunset cut him short with half an hour, but Venus had been seen in the act of transit. The transits of 1769, together with the methods suggested, during the interval since the last transit, for utilizing them in determining the solar parallax, are next dwelt on. A long and instructive chapter on transits and their conditions is then introduced, after which the subject of the coming transits is taken up. As the book was put to press just before the late transit, it is of course included among the latter.

THE UNSEEN UNIVERSE; or, PHYSICAL SPECULATIONS ON A FUTURE STATE. 212 pages. New York: Macmillan & Co. 1875. Price, $1. In paper, 60 cents.

WE briefly announced this work in the June MONTHLY. It has been for some time anticipated with an earnest interest by some, and a vague curiosity by others, as rumor made it the joint production of two eminent *savants*; and it was expected that a crushing double shot would be poured into—somebody. It has been since stated that the book is due to Prof. G. P. Tait, the eminent mathematician of Edinburgh, and Prof. Balfour Stewart, of Owens College, Manchester, author of various works on physics, among which is the little volume on the "Conservation of Energy," published in the "International Scientific Series." These are strong men; the subject is one of profound interest, and is certainly handled in an original way, and the volume, besides, is cheap, and in excellent type. The best analysis that we have

seen of the work, and a better one than we could prepare, appeared in *Nature*, and we shall best serve our readers by quoting freely from the review:

"The preliminary chapter states the fact of the all but universal belief in, or aspiration after, immortality. It admits that that doctrine is inconsistent with the doctrine of continuity as generally understood and as applied solely to the visible universe. It accepts and explains the principle of continuity in the fullest sense, and it attempts to reconcile it, as thus apprehended, with the doctrine of immortality. Incidentally—out of the apparent waste of energy in space, and on other indications chiefly teleological—it constructs an hypothesis of an invisible universe, perhaps developed out of another invisible universe, and so on *ad infinitum*. It is another consequence of the theory that our natural bodies are probably accompanied by a sort of invisible framework or spiritual body, and that the phosphorus and other substances of which the natural body is built up are not really identical with these elements in their ordinary condition of inorganic atoms, but are somehow transubstantiated by the coexistence, along with the mere chemical substance or with its chemical properties, of this invisible, imponderable, immaterial, accompanying essence, which derives a kind of *vis vivida* from a connection with the unseen universe. The passage from the visible universe to the invisible seems to be made intelligible to the authors by the existence of the ether, a substance into which energy is continually being passed, and into which it is perpetually, and, so far as any obvious or sensible effect is concerned, finally, absorbed.

"As a first postulate the authors assume the existence of a Creator. Finite beings, creatures, are conditioned by the laws of the universe, and it is in these conditions that we must seek to discover its nature. The first pair of subjects for human thought are matter and mind, and the materialists tell us that, whereas mind or mental activity never exists without being associated with some forms of matter, we may perfectly conceive matter, as for instance a block of wood or a bar of iron, existing without intelligence. Is mind, then, the dependent—is there nothing in matter which serves as the vehicle of intelligence different from all other matter? The authors answer that we have no right to assume that the brain consists of particles of phosphorus or carbon such as we know these substances chemically, that we cannot say that there may not be something superadded to their chemical and physical qualities. They dwell upon another fact—the fact that individual consciousness returns after sleep or trance; a fact inferring some continuous existence. The assumptions of the materialist are less inevitable than he supposes. Turning to mind, finite conditioned intelligence, the authors ask, what is essential to it? It must have some organ by which it can have a hold upon the past, and such a frame and such a universe as supply the means of activity in the present. Outside they find physical laws, and they look on the principle of continuity as something like a physical axiom. By this principle we are compelled to believe that the Supreme Governor of the universe will not put us to permanent intellectual confusion. It is in the nature of man, certainly in the nature of scientific man, to carry the explanation of every thing back *ad infinitum*, and to refuse perpetually to grant what is perpetually demanded of him, that he has arrived at the inexplicable and unconditioned. On this principle scientific men have supposed themselves to prove that the physical universe must one day become mere dead matter. The authors consider that this is a monstrous supposition, although they grant that the *visible*, or by-sense-perceivable universe, *must in transformable energy, and probably in matter*, come to an end. They think that the principle of continuity itself demands a continuance of the universe, and they are driven to believe in something beyond that which is visible as the only means of explaining how this system of things can endure in the future, or can have endured forever in the past. They see a visible universe, finite in extent and finite in duration, beyond which, on both sides stretching infinitely forward and infinitely backward, there is an invisible, its forerunner and its continuation. It is natural to infer that these two invisibles must meet across the existing finite visible universe. As we are driven to admit the invisible in the past and in the future, there must be an invisible framework of things accompanying us in the present.

"What, then, is this present visible universe; and can we point to sure signs of this invisible substance which accompanies what may prove after all to be the mere shadow of things? Matter has two qualities. The first is that it is indestructible; the second, that the senses of all men alike point to the same quantity, quality, and col-

location of it. Our practical working certainty of the existence of matter means: 1. That it offers resistance to our imagination and our will; and, 2. That it offers absolute resistance to all attempts to change its quantity. Certain other things—notably energy—are in the same sense conserved, and, if we recognize the transmutability of energy of motion into energy of position, we may say that energy is equally indestructible with matter itself. But energy is undergoing a perpetual self-degradation. All other forms of energy are slowly passing into invisible heat-motions, and when the heat of the universe has ultimately been equalized, as it must be, all possibility of physical action or of work will have departed. Mechanical effort cannot longer be obtained from it. The perfect heat-engine only converts a portion of the heat into work; the rest is lost forever as an available source of work. There is indeed a sort of wild and far-off possibility by which a little more work *might* be got out of a uniform-temperature universe, if we could suppose Clerk-Maxwell's demons—' mere guidance applied by human intelligence '—occupied in separating those particles of a heated gas which are moving faster than the average from those which are moving slower. But this is but a broken reed to trust, and it would at the best avail us little. What must happen in the existing physical system would be this: the earth, the planets, the sun, the stars, are gradually cooling; but infinitely numerous catastrophes, by which the enormous existing store of energy of position may be drawn upon, may over and over again restore unequal temperature. The fall together, from the distance of Sirius, of the sun and another equal sun would supply the former with at least thirty times as much energy as can have been obtained by the condensation of his materials out of a practically infinite nebulous mass of stones or dust. But these catastrophes can only delay the inevitable. If the existing physical universe be finite—and the authors never seem to realize the speculative possibility that it may not be so—the end must come, unless there be an invisible universe to supplement and continue it.

"What is the ultimate nature of matter, and especially of the ether, which is the vehicle of all the energy we receive from the sun? There have been four theories, for each of which something may be said. There is the Lucretian theory of an original, indivisible, infinitely hard atom, 'strong in solid singleness;' Boscovich's theory that the atom or unit is a mere centre of force; the theory that matter, instead of being atomic, is infinitely divisible, practically continuous, intensely heterogeneous; and, finally, the theory of the vortex-atom, a thing not infinitely hard and therefore indivisible, but infinitely mobile, so that it escapes all force which makes effort to divide it. What we call matter may thus consist of the rotating portions of a perfect fluid, which continuously fills space. Should this fluid exist, there must be a creative act for the destruction or production of the smallest portion of matter. Whichever of these theories we adopt, we must explain the simplest affection of matter—that by which it attracts other matter. There seems little possibility of doing so. The most plausible explanation is in Le Sage's assumption of *ultramundane corpuscles*, infinite in number, excessively small in size, flying about with enormous velocities in all directions. These particles must move with perfect freedom among the particles of ordinary matter, and if they do so we can understand how, through the existence of the ultramundane particles, two mundane particles attract inversely as the square of the distance. On this theory the energy of position is only the energy of motion of ultramundane and invisible particles—and a bridge is built between the seen and the unseen. These ultramundane particles are something far more completely removed from all possibility of sensible qualities than the ether which Sir William Thomson has attempted to weigh. Struve has speculated upon the possibility that it is not infinitely transparent to light, and his calculations, based on the numbers of stars of each visible magnitude, lead him to suppose that some portion of the light and energy from distant suns and planets may be absorbed in it. The ether is thus a kind of adumbration or foretaste of the invisible world. It may have certain of the properties of that world which is perceived by sense, but it is probably subject only to a few of the physical conditions of ordinary matter.

"Let us look once more at the substance of the universe. We recognize that it is impossible to suppose any existing state but as the development of something preëxisting. To suppose creation is to suppose the unconditioned. Creation belongs to eternity, and not to time. This being so, it is difficult to believe in the vortex-ring theory, which regards the invisible universe as an absolutely perfect fluid. With an imperfect

fluid, the eternity of visible matter which the vortex theory requires, disappears. Such a visible universe would be as essentially ephemeral as a smoke-ring—so that we may accept it as possible, if not probable, that the visible universe may pass away—that it may bury its dead out of its sight. In its present state we have three forms of development — Chemical, or Stuff-Development, Globe-Development, and Life-Development. It is a question whether the ultimate atoms of chemists are really ultimate; whether some agent, like great heat, for instance, could not split them up into various groups of some primal substance like hydrogen. We see the prospect of a similar simplicity in the development of worlds on the theory of Kant and Laplace, which makes the systems of the universe the result of the gradual condensation of nebulous masses. In the end, all the masses of the universe must fall together—in the beginning there can have been no masses, every thing being nebulous and discrete, even if ordinary matter be indestructible. The last state and the first state of the visible universe are thus separated from each other by a finite duration. A like simplicity may be reached in the development of life. Darwin has made it at least possible that all life may issue from some primordial life-germ. The complete refutation of the doctrine of abiogenesis—the practical proof that life issues only from life—leaves us still bound to account for that germ. There is no doubt that species develop varieties which may ultimately become distinct species, although there is little indication that the varieties of what was once one species are ever separated like species originally different, by a barrier of mutual infertility. A sufficient length of time might enable us to overcome this barrier. In all our developments—the substance-development, the globe-development, the life-development—we are thus brought, in the end, to a something which we are not yet able to comprehend.

"Turning from matter to the phenomena which affect it, we notice one singular set of phenomena in which things insignificant and obscure give rise to great lines of events. A whole mass of water, the temperature of which has been reduced below the freezing-point, suddenly crystallizes on the slightest starting motion; a whole series of tremendous meteorological phenomena, such as hurricanes in the Indian Ocean, happen because certain positions of Mercury and Venus affect the sun's atmosphere, causing spots in his, and the condition of the sun affects the earth. Like the complicated series of effects which follow the pulling of the trigger of a gun, the effects are utterly disproportionate to their causes. Man is a machine of this unstable kind—some trivial change affecting the matter of the brain is all that is needed to set him in motion. May not other beings be capable of touching what we may call the hair-triggers of the universe? Whatever these agencies are, angels or ministering spirits, they certainly do not belong to the present visible universe. The writers examine the sacred records to confirm their speculations."

Proceedings of the American Association for the Advancement of Science. Twenty-third Meeting, held at Hartford, Conn., August, 1874. Salem, 1875.

This is the annual volume of the American Association, and represents the results of the Hartford meeting in 1874. It opens with the address of the retiring president, Prof. J. Lovering, of Harvard College.

This is concerned with what is called "the great problem of the day," viz., "How to subject all physical phenomena to dynamical laws," and gives an abstract of the various theoretical views on "action at a distance," which, although brilliant, is not fully satisfying.

The practical moral enforced by the address seems to be one designed for American physicists; the moral is that, "unless our physicists are content to lag behind and gather up the crumbs which fall from the rich laboratories and studies of Europe, they must unite to delicate manipulation the power of mathematical analysis."

It is quite true that the mathematics are sadly neglected among us, and of this we have a striking confirmation in this very volume: the only mathematical paper in the whole book is one which demands forty-seven lines for itself, and this is a new demonstration of one of the theorems of Euclid. It is indeed true that our physicists, our scientific men generally, and above all our students, need to recognize, far more than they now do, the value of analysis as a means of research.

We must not forget, however, what in fact is pointed out in this very address, that the basis for mathematical analysis applied to physics must come from labo-

ratory experiments: and certainly in this respect America has little to fear from importations of "crumbs." The laboratories of the Stevens Institute of Technology, of the Lawrence Scientific School, of Columbia College, of the University of New York, and others, bear faithful witness to thorough work, and to real advances in the most delicate researches of physics. It must be remembered, too, that great works of analysis are not plenty in any country, and we think that the masterly works of Ferrel, on the theory of the tides, redeem America from reproach for 1874 at least.

The "Report of the Committee on the Preservation of Forests" follows, and from it we learn that this important subject is now before Congress in a proper form, and that we may reasonably hope for some action from that body.

The Association is divided into two sections, A and B, the first of "Mathematics, Physics, and Chemistry," the second of "Natural History," and we can judge of the attention given to the various subjects by noting the number of papers devoted to each.

Thus we find for *Mathematics*, one; for *Astronomy*, three; for *Physics*, eight; for *Chemistry*, eight; for *Statistics*, one. This completes the work of Section A. In the section of "Natural History" we find for *Geology*, eleven papers; for *Paleontology*, one; for *Botany*, four; for *Zoölogy*, twelve; for *Anthropology*, two.

It cannot fail to be noted that on the whole this volume of 378 pages is a decided improvement on its predecessor of 669 pages, particularly in the character of the publications printed. The printing committees seem to have exercised a careful scrutiny of the work put before them, and their selection has made the volume not uncreditable to American science.

We had not intended to notice in detail any of the separate papers, since they are all to be seen in the volume itself, and since very full reports of them were published by the *New York Tribune* during the time of the meeting; but it is impossible to avoid calling attention to a paragraph in a paper by Dr. Asa Gray, the great botanist of Cambridge, on the growth of the trunks of trees. The question was raised as to whether a tree in growing expanded its main trunk vertically in those parts once formed; experiments were made to determine this point by Dr. Gray, and the experiments and theories of various correspondents are analyzed by him. Of one he says:

> [This] correspondent, "who has read in the older books on the structural botany a good deal more than there is any foundation for, about a collum, or collar, between the root and the stem, and who states that the wood is here of horizontal instead of vertical fibres, or cells, suggests that the trunks lengthen at their base only, and by the increase of these horizontal wood-fibres, formed one above the other, at the level of the ground. Now, in the first place, this supposed collar was only between the primary root and stem of a seedling; so that only trees raised from seed could be lengthened by its growth, not those originated from suckers, layers, or cuttings. Next, trunks lengthened in this way would come to have the butt-log composed of wood with horizontal fibres, which I think nobody ever saw. And, finally, there *is* no such collar, even in the seedling, with horizontal fibre, interposed between the root and stem."

We quote this to show that in some instances botany is more than an exact science—it is a precise one.

The Maintenance of Health. By J. Milner Fothergill, M. D. 366 pages. New York: G. P. Putnam's Sons, 1875. Price, $2.00.

This book is, in the author's first and last words, "a medical work for lay readers," "writ out of great good-will unto my countrymen." The book is divided into thirteen chapters, with the salient points summed up at the end of each in a list of propositions. The first chapter treats of health, what it is, and how maintained laying down many propositions, among which are that there are different types of health, and that bodily and mental health must go hand-in-hand. The next three chapters treat successively of health in youth, or the period of growth; health in adult life; and health in old age, or the period of decay. Chapter V. discusses the quality, quantity, and properties of food and clothes. Chapter VI. is given to stimulants and tobacco, in which the author uses these propositions: "Alcohol is a re-

spiratory food, not a poison under all circumstances, as held by some; as a stimulant, it enables the system to use some of its reserve force; when the brain is worried, alcohol may be taken at bedtime with benefit; tobacco in moderation is harmless, except to the young and growing." Chapter VII. treats of the "Effects of Inheritance;" VIII., "The Election of a Pursuit in Life;" IX., "Overwork, and Physiological Bankruptcy;" X., "Mental Strain and Tension," with this as one of its propositions: "Chloral hydrate is a much more objectionable narcotic than either opium or alcohol." In Chapter XI., under the heading "Hygiene," the author treats, in separate sections, of "The House we live in;" "The Air-Supply;" "Ventilation;" "The Water-Supply;" "Sewage;" "Fevers;" "Disinfectants and Antiseptics;" "Vaccination;" "Accidental Poisoning." Chapter XII. is devoted to the treatment of "Emergencies," Chapter XIII. discusses the influence of climate and telluric conditions on health, and concludes the book. The author's style is easy and entertaining, and his book contains a large amount of valuable information.

The Geological Story briefly told. An Introduction to Geology for the General Reader and for Beginners in the Science. By James D. Dana, LL. D., Professor of Geology and Mineralogy in Yale College. 263 pages, 12mo. New York: Ivison, Blakeman, Taylor & Co., 1875. Price, $1.50.

Now that the stories of science are being simplified and told in so many ways, that everybody may hear them, Prof. Dana comes forward and briefly tells *his* favorite story—the geological one. This little book is one of the most interesting and instructive of the briefly-told stories of science published. It fills well the place for which it was intended—an introduction to geology for the general reader and for beginners in the science—and will be specially welcomed as a source of ready and concise information in this branch of study. Scientific terms are defined as they are met with, and the whole narrative is made as popular as possible. After some prefatory suggestions about practical out-door study, the subject of "Rocks, or what the Earth is made of," embracing constituents of rocks, kinds of rocks, and structure of rocks, forms the opening part of the book. Part second treats of the methods by which the different kinds of rocks have been made, and the causes in geology which have formed the geographical features of the earth's surface. Part third deals with historical geology, tracing the succession in the formation of the rocks of the earth, and the progress of life—plants and animals—from the simpler forms of early time up to man. The book is finely illustrated.

Art-Life and Theories of Richard Wagner. Selected from his Writings and translated by Edward L. Burlingame. New York: Henry Holt & Co., 1875.

There is probably no subject which a hasty public opinion would more quickly exclude from the cycle of the sciences than music; and public opinion would be, as usual, both right and wrong. The strictly *scientific* part of music—the systematic collection of the general principles and leading truths relating to it—is of no immediate use to the composer; neither is any particular theory of atoms important to the analytic chemist. Chemistry, however, although at present chiefly an art, claims a place among the sciences, and the modern school of music formulates its theories in scientific guise, and demands a judgment on intellectual and scientific grounds. We must not forget, too, that among the seven sciences of the ancients music was the peer of geometry.

This volume of selections and translations from the writings of Wagner, the founder and the chief exponent of the new school of music, is almost the only means by which Americans can arrive at a conception of the principles which animate it, and of the ideals which it seeks. Wagner is a voluminous writer, and many of his essays are of a quite special nature, so that great judgment was required in selecting such of them as should give the reader a rounded conception of Wagner as a man, as a composer (in reference to his own works), and as a musician, or musical theorist (in reference to the function which music should fulfill, and to the means for attaining its ideal).

With only a casual acquaintance with Wagner's complete works, we may yet un-

hesitatingly say that the selection has been very judiciously made; and, indeed, any one, after reading the volume, will obtain a definite conception of Wagner's personality, which will be felt to be a true conception.

The book opens with a brief introduction, in which the translator explains some of the difficulties which stand in the way of putting Wagner's German into tolerably plain English, and then proceeds to Wagner's autobiography; or so much of it as brings the account down to 1842, since which time his life has been in a great degree a public one.

His youth was idle and stormy, and it was only after hardship and some real misery that he came to thorough work; the determining cause of his action seems to have been an intellectual one, rather than an impulse.

Following the autobiography, come three essays much of the same class: "The Story of the First Performance of an Opera," "A Pilgrimage to Beethoven," and "The End of a German Musician in Paris."

The impressions with which one comes away from the reading of the autobiography are strengthened and amplified by these sketches.

These belong to Wagner as a man, and confirm the rather unpleasant impression which his own life, as written by himself, conveys; he seems to have let his enthusiasm degenerate into waywardness, or rather waywardness was his enthusiasm, and his aspect toward the world in general is disheartening. We are speaking now of Wagner as he was in his earlier years, before 1842, and we recognize the propriety of the selection of the second and third of these essays as exponents of his feeling at that time. Indeed, that must be the sufficient excuse for their selection, as the fictions themselves are of the slightest and most trivial description.

From this point onward we have to deal with quite another phase; not, indeed, with another Wagner, for the unpleasant impression of his personality remains, but with the same Wagner under new impulses or new intellectual motives. To this period belong the two essays on "Der Freischütz," which must be classed among the best specimens of musical literature extant.

They are charming for the keen appreciation of the points involved, and for the skill in which characteristics, good and bad, are brought out and set over against each other. Although these, in time, are of the same epoch as the ones previously noticed, they are an outcome of a decidedly higher phase of feeling.

Then follow essays on the music of the future, the purpose of the opera, musical criticism, and on the production of "Tannhäuser" in Paris. These are fine in all ways, and show how Wagner's musical theories were taking shape, and define, when taken together, what that shape is. We had meant to give this in brief, but find the task no light one, and we must refer the reader to the essays themselves for an explanation. Suffice it to say that Wagner proves, in such a way that all must follow him, that the form of the opera produced by the Italian school is entirely inadequate, not to say absurd. It is absurd poetically, dramatically, and above all musically. He also explains in what way he proposes to remedy these defects, and despite much "fine writing" and vague disquisition an idea may be had of his scheme. Two essays on the plan of the Grand Opera-House at Baireuth show that his ideas may be put into definite brick and mortar, although hard to formulate into words.

The "Legend of the Nibelungen" gives an excellent idea of his skill as an author, and would show to any one not acquainted with his operas that the dramatic situations and the swing and progress of a dramatic climax are likely to be fully understood and adequately treated by him. This volume gives, it seems to us, an adequate idea of Wagner as a man and as a musical theorist. As a man he is not lovable, scarcely admirable. One would call him acute rather than profound. As a theorist, it is impossible to give a suitable judgment in the short limits of a review, which shall not at the same time offend both his friends and his enemies. Any such judgment must be in a large degree personal, and therefore imperfect. Shall we say that *dramatically* and *poetically* he stands alone in *opera*—that *symphonically* he has not yet reached the limits of his master Beethoven—that in dramatic vocal forms R. Franz and Schu

mann are worlds beyond him? He is but the expression of his time—a vague yearning for perfection—an embodied dissatisfaction with his age. He has not, nor will he have ever, reached the dramatic, poetic, and symphonic unity which Händel attained in the "Messiah" a hundred years ago.

His efforts, we think, will be, and have been, of the highest use, and it will be long before music again has such a master of poetry, drama, and song, for a votary; still we sympathize heartily with the accomplished musical critic of the *Tribune*, who speaks of the new school thus:

"The day has gone by when Liszt and Wagner could be decried as mad fanatics. The new music is gaining ground; it is played and sung in every city of the civilized world; we *must* listen to it whether we like it or not; and the wisest of us have determined to like it if possible, or at least to pretend to like it if we can do no more. And yet it is rather saddening to think that the symphony of the future is to be like this Dante symphony (Liszt)—poetic, imaginative, forcible, and thoughtful as it is, but so terribly *hard*. . . .

"It is saddening to be told that there shall never be another Haydn; that the world shall never be gladdened with the bright fancies and graceful sentiment of a new Mozart; that even the idealities of Schumann are fashions of the irrevocable past; that we shall wrestle with melodies as if they were Greek roots, and suffer all the pangs of purgatory before we can work out a tune."

What the new music is, we have learned from Thomas long ago, and we fear that subtile master has made us like it all too well for his and our true progress in art: what its theories and ideals are, we learn authentically for the first time in English speech from this book, and we welcome it, if only that it puts the dogma into a definite, and therefore refutable, form.

Berliner Astronomisches Jahrbuch für 1877. W. Foerster und F. Tietjen. Berlin, 1875.

The *Berlin Jahrbuch*, which corresponds to the English *Nautical Almanac* and to the American *Ephemeris* in part, is published yearly in Berlin, under the charge of the Director of the Berlin Observatory. It differs from the English, and American, and French *Ephemerides*, in that it is a purely *astronomical* year-book, the nautical data being given by a separate publication—the *Nautisches Jahrbuch*—which is at present under the direction of Bremiker, who, as well as Foerster, was one of Encke's pupils, while Encke was the conductor of the *Berlin Jahrbuch*.

The present volume differs little from the preceding ones, but it is fully up to the requirements of the science. It gives: 1. Ephemeris of the Sun and Moon, 100 pages; 2. Geocentric places of the major planets, 57 pages; 3. Heliocentric places of the major planets, 12 pages; 4. Appearances of Jupiter's satellites and Saturn's ring, 8 pages; 5. Mean and apparent places of certain fixed stars, etc., 55 pages; 6. Eclipses, etc., of the year, 24 pages; 7. Auxiliary tables, etc., 6 pages; 8. Ephemeris of the minor planets (asteroids), and list of their approximate geocentric places, 111 pages.

It will be seen that astronomers are well provided for in data from this *Ephemeris*, which, on the whole, is more compendious than any other. It has not, for example, the hourly ephemeris of the Moon which is given in both the English and American *Ephemerides*, but in general it is more convenient than either of these. Its specialty, so to say, is in its ephemerides of the asteroids. Of these, 142 were known at the time of the publication of this volume, and complete ephemerides of 136 are given. It may not be amiss to give a few details with regard to these small planets, as in general little is known of them: 123 of these asteroids have been observed in three different years, and, of these 123, 112 have their orbits so well settled that their places will be sufficiently exact for some time. One of the 123 (*Frigga*) has been observed during three oppositions, and, although its orbit should be well determined, it has not been again found. *Silvia* and *Clymene* were for some years lost, but they have now been successfully sought for and observed. *Maia*, *Dike*, and *Camilla*, of the first 123, have been observed only during one year, and are for the present lost. *Liberatrix* is also lost, and not enough time has elapsed since the discovery of the remaining 13 planets to be certain of their orbits.

It may be said that of the 142 planets known up to February, 1875, at least 92 have their orbits *fully* determined, while only *four* are for the present lost. This is a most admirable showing both for the intrepidity of the computers and the assiduity of the observers. Since February three new planets have been found, two by Dr. Peters, of Clinton, New York, apparently in honor of his safe return from a most successful expedition to observe the transit of Venus, and one by Borelly, of Marseilles. As a *tour de force* in finding asteroids may be mentioned Watson's discovery of No. 139 in Peking, China, during the residence of the American Transit-of-Venus Expedition in that place. It may add to one's conception of the assiduity of astronomers if we remember that in 1800 not a single one of these asteroids was known.

Astronomical and Meteorological Observations made during the Year 1872, at the United States Naval Observatory. Washington: Government Printing-Office, 1874.

This is the eighteenth regular volume of the Observatory publications, which were begun in 1845, and have been continued annually since that time, with the exception of the years 1853 to 1861.

During 1872 the instruments at the Observatory were:

1. The Meridian Transit of 5 inches aperture, and 7 feet 1 inch focal length.

2. The Mural Circle of 4 inches aperture, and 5 feet focal length.

3. The Prime Vertical Transit of 4.8 inches aperture, and 6 feet 6 inches focal length.

4. The Transit Circle of 8.52 inches aperture, and 12 feet 1 inch focal length.

5. The Equatorial of 9.6 inches aperture, and 14 feet 4 inches focal length.

6. Meteorological Instruments.

Of these instruments the first and third were not in use during the year, for lack of observers.

The mural circle was employed during the year in observations of stars whose right ascensions had previously been determined by the transit instrument, and which are included in the Washington "Catalogue" of stars, in the observation of a large number of circumsolar stars from the British Association "Catalogue," and in a few miscellaneous observations, in all about 1,400 observations.

The transit circle was devoted to the observation of the stars of the American *Ephemeris*, to observations of miscellaneous stars, and of the Sun, Moon, planets, and asteroids (of the last, however, only *eight* were observed during the year); 697 stars are found in the "Catalogue," and of these, together with the Sun, Moon, and planets, about 3,700 observations were made. The methods of reduction have remained substantially the same since the instrument was mounted. It is to be noted that the observations made of stars reflected from the surface of Mercury lead to results more and more discrepant each year, so that the latitude deduced from direct observations differs from that from reflex observations by nearly three seconds of an arc in 1872; under these circumstances all the reflection observations of 1871 and 1872 have been rejected.

The equatorial has been used in the observation of the asteroids, of which ten have been observed during the year (a very fine series having been made for three months on *Alceste*), of the companion of Sirius (measures on twelve nights), and of occultations (ten *immersions* and five *emersions*). Besides this a good series of observations was made on the comets of Encke and Tuttle.

The regular meteorological observations (seven observations in twenty-four hours) have been kept up and are given in detail and in means. The indications of the barometer, wet and dry bulb thermometers, maximum and minimum thermometers, solar thermometer and rain-gauge, are recorded at suitable times, and the *direction* and *force* of wind (*force* by estimation only) and cloudiness of sky are also noted. No self-recording meteorological instruments are provided.

The *personnel* of the Observatory consisted, in 1872, of a superintendent (rear-admiral U. S. Navy), of five Professors of Mathematics and three aids (observers), of an instrument-maker, and three watchmen (meteorological observers).

Besides this force several officers of the line of the Navy were detailed to take charge of the chronometers of the Navy, which

are kept at the Observatory, and two Professors of Mathematics were employed on duties other than those of observing.

Storms, their Nature, Classification, and Laws, with the Means of predicting them by their Embodiments, the Clouds. By William Blasius, formerly Professor of the Natural Sciences in the Lyceum of Hanover. Philadelphia: Porter & Coates. Pp. 342. Price, $2.50.

This volume is an interesting contribution to the literature of an important branch of meteorology. It is a result of many years of observation, and the conclusion of the author is that existing theories of the nature and laws of changes of weather are intrinsically erroneous. Instead of an area of barometric depression being the storm itself, and the *cause* of the movement of the air-current, the storm is the conflict of air-currents of different temperatures, and the barometric depression the *effect* of their movement. Hence atmospheric appearances and phenomena more truly indicate and forecast storm-movements than does the barometer.

The air-currents arise primarily from difference of temperature in the equatorial and polar atmospheres, and in the upper and lower regions of air. In the tendency to restore and maintain the equilibrium thus disturbed originate all the movements known as storms.

These movements will be—1. Vertical, that is, between the lower and upper strata of air. 2. Horizontal, or between the poles and equator.

By these movements, in connection with local circumstances, all modifications of storms are produced. In temperate regions the horizontal movement of storms is most frequent—the vertical most frequent and violent in the tropics.

The formation of a cloud tells us not only that vapor is being condensed in the air, but that warm and cool currents have encountered each other.

In the horizontal movement, the cold and warm currents overlap each other, the vapor-laden warm air from the equator rising over the colder current. A consequence is, the warm air ascends until its waves reach an elevation where condensation takes place along their crests, producing flecks and bars of cloud-caps of the aërial waves. These bars of cloud sometimes span the heavens, rising in the southern horizon, heralding the approach of a northeast storm.

Not until these reach the zenith, says the author, does the barometer announce the approaching change. The storm-area is where these opposing currents encounter each other. The rotary theory of storms he considers defective, and says that the wind blows in all parts of a storm-area in direct lines from the circumference to the centre. So we encounter wind from different directions as the storm passes.

According to the author, observation of the clouds, which are an embodiment of the storm, affords earlier and more trusty data of its approach than the barometer, and the rules for navigators based on the cyclone theory are worse than useless. The theory that storms progress by working their own way, that is, by condensation and rainfall in their front, he says is like a wheelbarrow drawing the man after it.

The work is, in many respects, suggestive, and will be read with interest.

Progress-Report upon Geographical and Geological Explorations and Surveys, west of the One Hundredth Meridian, in 1872, under the Direction of Brigadier-General A. A. Humphreys, Chief of Engineers, U. S. A., by First-Lieutenant George M. Wheeler, Corps of Engineers in charge.

This thin pamphlet of some 55 pages is really but a fragmentary sample of the long-expected quarto report of the Government surveys of this singularly wild and interesting field. Thus a few specimen full-page plates are given, especially of the weird-like cañons; also a map. The plan of composition is commendably judicious, in that it avoids the journal form; for although it is much easier to sustain a certain sort of interest by means of the narrative method, yet in a scientific work such a form is in great danger of unprofitable extension. Still the story is told in a graphic way, with the results classified, thus giving plan and system, which are indispensable to scientific work. As a sample of the best sort of scientific work, for the reason that it is

complete, and is a part with the above, which is as yet but fragmentary, we would instance Dr. Coues's "Birds of the Northwest," so full and yet so concise; so accurate, and yet so lively. It seems to be for them all a promise that the great Government reports shall stand in striking contrast with that of the famous New York survey—so unmethodical and verbose; so excessive in quantity and so turgid in style.

Meteorological Observations in Colorado and Montana.

This publication is a sort of appendix to the report of Lieutenant Hayden for the year 1874. It consists of tables, based upon the observations of meteorologists stationed at Bozeman, Judith Basin, and Trout Creek, in Montana, and on the summit of Mount Lincoln, at Fairplay, and at Cañon City, in Colorado. The observations at these various places were made three times a day, for the whole of the year 1873, and during the early part of 1874.

List of Elevations, principally in that Portion of the United States west of the Mississippi.

These lists, compiled and arranged by Henry Gannett, M. E., form part of Lieutenant Hayden's Report in the Geological Survey of the Territories. Table I. gives the elevation of towns and cities; Table II. those of mountains in the United States; while Table III. states the elevations of various mountains in other countries. The Twin Lakes, in Colorado, have an elevation of 9,357 feet, being situated at the greatest height of any lakes in the United States. Of the States and Territories west of the Mississippi, Colorado has the highest mean elevation, 6,600 feet, and Arkansas the lowest, 350 feet.

Annual Address before the Alumni of the Medical Department of the University of Pennsylvania. By Cornelius G. Comegys, M. D.

This address contains many serious and timely reflections upon such topics as state medicine, the physical basis of mind, the effects of cerebral overwork, etc. The history of medical sciences in the present century is briefly but ably sketched. Finally, the author advocates a reform in medical education. The age of teaching by lectures has almost gone by; the demands of science now are demonstrations. The student must be taught to acquire his anatomy, physiology, physics, chemistry, pathology, materia medica, and practical medicine, with his own hand and eye. The classes of clinical medicine, above all, should consist of small groups, in order to secure the closest personal scrutiny of the phenomena of disease, and of the effects of modes of treatment.

Bulletin of the United States Geological and Geographical Survey of the Territories. Numbers 2 and 3, Second Series.—No. 2 contains able papers by Ridgway, Coues, Gill, and Ingersoll. These papers are severally contributions to zoölogical science, and in this intense technical shape are meant to commend themselves simply to hard workers in the field. No. 3 is mainly topographical, and contains several plates and maps.

The Brooklyn Journal of Education.—The external appearance and *matériel* of this publication are very attractive, and by themselves alone are calculated to win for it public favor. The editorial management appears to be no less excellent; and with both of these conditions combined there is no reason why the *Brooklyn Journal of Education* should not meet with distinguished success. Among the articles in the first number is one on the Packer Institute, being the first of a series on the educational institutions of Brooklyn. Dr. Jerome Walker writes concerning the *physique* of public-school teachers. "The Philosophy and Methods of Primary Instruction" is treated by James Cruikshank. The periodical has special science and art departments. $2.50 per annum.

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PUBLICATIONS RECEIVED.

Six Notes de Chimie Moléculaire. Par M. Gustave Hinrichs. Paris: 1873–'75.

Moments and Reactions of Continuous Girders. By Mansfield Merriman, C. E. Pp. 23.

Principia, or Basis of Social Science (Wright). Lippincott & Co.

Bad Health of American Women. By James E. Reeves, M. D. Wheeling, Va. Pp. 43. Price, 50 cents.

Animal Volition a Creator. By C. G. Forshey. (New Orleans Academy of Sciences.)

Papers read before the Pi Eta Scientific Society of Troy Polytechnic Institute. Pp. 74.

Oldbury. By Annie Keary. Philadelphia: Porter & Coates. Pp. 420. Price, $1.25.

The Complete Arithmetic. *Also*, First Book in Arithmetic (Fish). Ivison, Blakeman, Taylor & Co.

Determination of Minerals by Blow-pipe (Danby). London: Field & Tuer.

St. Louis Public Schools.

Bulletin of the Bussey Institution.

Morgan Expedition, 1870–'71.

Archæological Researches in Kentucky and Indiana (Putnam).

Hygiene of the United States Army.

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# MISCELLANY.

**Fish-Culture.**—The results so far attained in this country in the artificial culture of fish are eminently satisfactory, and the efforts made by the various fisheries commissions to increase the supply of food for the people are worthy of all commendation. Naturally, there exists a lively public curiosity to know the processes of fish-culture, and information with regard to its history, its principles, and its methods, is heartily welcomed. In response to this general demand, Mr. Robert B. Roosevelt, Fish Commissioner of the State of New York, has given a public lecture on pisciculture, in which he very fully considers the subject in all its aspects. The lecture is very long, and we must be content with indicating only a few of its points. There are, he said, two divisions of fish in our country which are subjects of fish-culture, viz., the *Salmonidæ*, or salmon-tribe, and the *Alosidæ*, or shad-tribe. Under the former head are included the salmon, the trout, the salmon-trout (or lake-trout), the white-fish, and the California salmon. The *Alosidæ* are represented in pisciculture only by the shad, as yet.

The first point in fish-culture is to obtain the spawning-fish in proper condition. In the *Salmonidæ*, the eggs, when in a perfectly ripe condition, lie free in the abdomen, and may be extruded by gentle pressure. They are caught as they fall in a basin, and are vitalized by coming in contact with the milt from the males. Formerly, the practice obtained of having this basin full of water, it being supposed that this arrangement more nearly reproduced the natural conditions; but subsequent discoveries led to a change of this method. The eggs are fertilized by the spermatozoa of the milt entering through the micropyle, and taking up board and lodging within. It was ascertained, however, in practice, that these spermatozoa are not fond of water, and, although very active when first emitted, soon drowned. They retain their vitality much longer when dropped among the eggs in a comparatively dry state, and this is the method universally pursued at present.

As soon as the operation is completed, the eggs are placed in hatching-troughs. These are made of various materials, but are simply long, narrow boxes, say twelve feet long by eighteen inches wide, and subdivided into compartments, to keep the eggs from crowding on one another. Cold spring-water, which has been carefully filtered by passing through several flannel screens, comes in at the head of these troughs, passes over the eggs, in one compartment after another, and escapes at the lower end. By this means the greatest dangers to the life of the embryo are avoided. Sediment and converæ cannot pass the screens, insects are kept out altogether, and ducks and eels are disappointed of their prey. The eggs require about two months to hatch, with the water at the temperature of 45°. They demand constant care and attention, for, if one egg dies or becomes diseased, it contaminates its neighbors. The advance of the process is, however, soon visible in the egg, either to the human eye or under the microscope. At last the pisciculturist will have evidence of his labors being successful. Some morning, on going to his troughs, he

will notice broken egg-shells in the water, and, on closer inspection, will observe wriggling nondescripts on the bottom, neither like fish nor eggs, but compounded of both. When they once begin to appear, they come in thousands, in millions, in myriads. The young need more water, at this time, but require less care; yet still they must be watched. The young fish may soon be turned loose into the stream.

If he is a salmon, after a few months' preparation to strengthen his sinews and test his power, he goes down to the sea, there to dwell, and feed, and grow, gaining wonderfully in size, drawing his sustenance from the exhaustless storehouse of the world, and coming back to man, in a few months, a magnificent embodiment of strength and beauty, bringing to the lord of the universe five or ten pounds of as delicious food as ever delighted a gourmand's palate, or satisfied a hungry man's stomach. If he is only a trout, a younger brother of the glorious family of the *Salmonidæ*, he will lurk about the bottom of some pond, or graze some pebbly mountain-brook, and struggle up to a half-pound or more before twelve months shall have rolled over his head.

**Heat evolved by Friction of Ice.**—Mr. A. Tylor, in a paper recently read before the Geographical Society of London—a synopsis of which was published in *Nature*—shows that heat evolved by friction of ice upon ice is an important element in glacial movement. By a simple apparatus he reduced ice to water in a temperature of 32°, at the rate of one and a quarter pound an hour, by friction only of ice upon ice, the pressure applied being but two pound to the square inch. By simple evaporation, the ice in the same temperature lost one-quarter of a pound in the same time.

In a temperature of 54° the production of water under friction was three and a quarter times greater than by simple melting when there was no friction.

The actual heat evolved by friction of ice upon ice is nearly the same as from oak upon oak, when well lubricated.

In the motion of glaciers great quantities of water are continually discharged, lubricating the bottom. Surface-melting of the ice Mr. Tylor considers insufficient to produce it. The bottom of a glacier, with its rasping under-surface of rock and sand, slides, to some extent, upon the bottom, and much heat is evolved in this way, but in innumerable fractures of the sides of the glaciers, of the surface-ice flowing on and over bottom-ice, there are friction and attrition, ice moving against ice, which melts it, and the water percolates through the fractures to the bottom.

In great glaciers the pressure is enormous. With ice a mile thick it is half a ton to the square inch, and the quantity of water produced increased accordingly.

**Economic Value of the Sunflower.**—The common sunflower is a native of tropical America, and there it sometimes attains the extraordinary height, for an annual plant, of twenty feet. It thrives in nearly every region of the inhabitable globe. In the south of Europe and in the northwest provinces of India it is cultivated to a considerable extent. In the latter country, sunflower-plantations are said to have a very beneficial effect in promoting the healthfulness of regions infested by malarious fevers. The seeds are valued as food for cattle and poultry, and an oil may be expressed from them which is scarcely inferior to olive-oil. One acre of good land will produce about fifty bushels of seed, each bushel yielding a gallon of oil. The seeds are also used like almonds for making soothing emulsions, and, in some parts of Europe, a food for infants is prepared from them. In tropical America the Indians make bread of them. The leaves are used as fodder for cattle, and the stalks, when burned, yield large quantities of potash.

The plant called Jerusalem artichoke is doubly misnamed; it has as little to do with the Holy City as the soup made from its tuberous roots has to do with the Promised Land, and yet the former is called Jerusalem (from the Italian *girasole*—sunflower), and the soup is called "Palestine," because it contains "Jerusalem." It got the name of "artichoke" from a resemblance in taste between its tuber and the flower-receptacles of the true artichoke, but it differs totally from that plant in botanical characters. The Jerusalem artichoke is a species of the sunflower, and, like all sunflowers, a native of

tropical America. It has a straight stem, eight or ten feet in height, and produces yellow flowers like those of the sunflower, but smaller. The thick, fleshy, perennial root produces a large number of tubers, in appearance not unlike potatoes. These are not as nourishing as potatoes, but, when properly prepared, are very palatable food, and make a very good soup. It is usually propagated by small tubers or by cuttings, like the potato.

**Toughened Glass.** — A process for increasing the cohesive power of glass has been invented by a French engineer, François de la Bastie. This process consists in heating the glass to a certain temperature and plunging it while hot into a heated oleaginous compound. The time occupied in the actual process of tempering is merely nominal, for directly on being heated to the requisite degree, the articles are plunged into the bath and instantly withdrawn. The toughened glass cannot be cut by the diamond, and hence when it is used for windows it must be cut to the proper size before it is tempered. Articles of this toughened glass, such as watch-crystals, plates, dishes, and sheet-glass, were recently exhibited in London, and experiments made to show wherein this material differs from common glass. Water was boiled in a saucer over a fire, and the saucer quickly removed to a comparatively cold place; it was unaffected by the sudden change of temperature. One corner of a piece of glass was held by the hand in a gas-flame until the corner became exceedingly hot, but the heat was not communicated to the other portion of the glass, nor was it cracked from unequal expansion.

The following experiment was then made to show how this toughened glass compared with common glass in power of resistance to fracture by the impact of a falling weight. The two pieces of glass to be tested were each about six inches square, and placed in frames, the weight being dropped upon the centre. With the ordinary glass, a two-ounce brass weight, falling on it from a height of twelve and eighteen inches respectively, did no damage, but at twenty-four inches the glass was broken into fragments. With a thinner piece of the toughened glass no impression was made by the same weight falling from heights ranging from two to ten feet, the weight simply rebounding from the glass. An eight-ounce iron weight, tried at two to four feet respectively, gave similar results. The height being increased to six feet, the glass broke.

Some of the public prints have ascribed to Bastie's tempered glass properties which the inventor himself has never claimed for it. Thus it has been qualified as "malleable" and "unbreakable." But Mr. Thomas Gaffield, of Boston, a perfectly competent judge, who has examined specimens of this tempered glass, thinks that the true value of this invention is by no means determined as yet. He perceives in it sundry qualities which detract from its usefulness. First, as we have stated, it cannot be cut by the diamond. Then, on being subjected to the sand-blast, it flies into small fragments. Many of the specimens seen by Mr. Gaffield were not transparent, but only translucent. In ordinary window-glass, if a large pane be broken, the fragments may be cut into smaller panes, but with the De la Bastie glass such economy is out of the question. From the fact that this improved glass, though before the public for a whole year, has not yet found a place in commerce, Mr. Gaffield is inclined to suspect that the invention is for some reason impracticable.

**Can Birds converse?** — Dr. Charles C. Abbott cites the following occurrence to show that birds possess some mode of conveying ideas to one another. In the spring of 1872 a pair of cat-birds were noticed carrying materials for a nest to a patch of blackberry-briers hard by. To test their ingenuity, Dr. Abbott took a long, narrow strip of muslin, too long for one bird conveniently to carry, and placed it on the ground in such a position as to be seen by the birds when searching for material. In a few moments, one of the cat-birds spied the strip and endeavored to carry it off; but its length and weight, however he took hold of it—and he tried many times—impeded his flight, and, after long worrying over it, the bird flew off for assistance. In a few moments he returned with his mate, and then, standing near the strip, they ap-

peared to *hold a consultation.* The chirping, twittering, murmuring, and occasional ejaculations, were all unmistakable. In a few moments these all ceased, and the work commenced. Each took hold of the muslin strip, at about the same distance in each case from the ends, and, taking flight simultaneously, bore it away. Soon there was much jabbering at the nest: the birds could not agree how to use the strip, and it was finally abandoned; but so, too, was the nest, and the birds left the neighborhood.

**Parasite in a Child's Mouth.**—At a meeting of scientific men lately held in New Brunswick, New Jersey, Prof. Lockwood exhibited a thread-worm which, he said, was sent him by a student of Rutgers College, two years ago, who found it in an apple which he was eating. It looked so like an animal parasite that the professor was puzzled to fix its character. He stated that Prof. Leidy had recently described before the Academy of Natural Sciences, at Philadelphia, the same worm, also taken from an apple; who also said that this worm was a parasite of the larva of the codling moth, whose grub, or larva, as is well known, infests the young apple, feeding inside of it, and thus causing it to fall from the tree to the ground, when the larva leaves the fruit and enters the ground, in which to pass its pupa state. Thus the worm, whose name is *Mermis acuminata*, was really an animal parasite, sustaining its own life apparently by a vegetable diet, after the death of the larva codling, either by absorption, or its own consumption of it. Dr. Leidy called the attention of the Academy to the fact that twenty-five years ago he described before them the same entozoön taken from the mouth of a child. At that time he was ignorant of the origin of the parasite. It now seems fair to infer that the child had been eating an infested apple, and that the worm had a second time changed its *nidus* for that of the child's mouth.

**Summer Temperature of Scotland.**—Mr. McNab, Director of the Edinburgh Botanic Garden, last year published some facts going to show that the mean summer temperature of Scotland has been growing colder during the last two or three generations. According to Mr. McNab, sundry plants which thrived in Scotland fifty or seventy-five years ago can now scarcely be grown there. Mr. William Tillery communicates to the *Gardener's Chronicle* several other facts confirmatory of McNab's conclusions. Forty years ago, nearly all the gardens of note in South Ayrshire used to exhibit at the horticultural shows peaches and nectarines grown on walls in the open air. Some good white and black figs were likewise ripened on the open walls in favorable summers; but this is of very rare occurrence now. At the present time, gardeners in the most favored districts of Scotland and in Northern and Midland England are lamenting the unproductive state of their peach and nectarine trees in the open air. A weather-register, kept for the last thirty-eight years, shows that of late years the winters have been more open, the frosts in the spring months later and more severe, and the rainfall more irregular, than formerly.

**International Weather Reports.**—It has been proposed to establish an exchange of telegraphic weather reports between the Signal-Office at Washington and the meteorological bureaus of the various countries of Europe, and it is claimed that such exchange would be likely to afford valuable data for forecasting the weather on both sides of the Atlantic. Mr. W. Clement Ley, who has worked for a considerable time at the comparison of United States with European weather-charts, holds that such exchange would be undesirable for Europe, on the following grounds: 1. Only a small proportion of the storms experienced on the American side of the Atlantic can subsequently be distinctly traced in Europe at all. 2. Of those thus traceable, the majority are felt severely only in the extreme north of Europe, and are not productive of serious results on the coasts of Britain, France, or Denmark. 3. The velocity of their progress varies indefinitely, and could not be deduced from the velocity of the currents experienced in them, even if the latter were not variable also. 4. Many of the most destructive European storms occur when pressures over the Eastern United States coast

are tolerably high and steady. In such instances attention to the telegrams would in all probability mislead. In conclusion, Mr. Ley says: "The connection between the weather periods on the two sides of the Atlantic is one of the problems which the progress of research is steadily, though slowly, attacking. But such research can be carried on without embarking on a system of weather telegraphy, which is unlikely to be practically beneficial, and the failure of which might rather tend to bring this branch of the science into disrepute."

**Where do the Grasshoppers belong?**—Prof. Riley's Seventh Report contains most valuable facts relative to the natural history and geographical distribution of the grasshopper (*Caloptenus spretus*) which has caused so much human suffering by its destruction of crops in the Western part of this country. It appears, from the Report, that the late Mr. Walsh, State Entomologist of Illinois, had previously predicted that the insect would not reach the Mississippi River, and, so far as known, subsequent facts bear out the statement, although the reasons stated for the limitation of the species to its present territory are not entirely satisfactory. Prof. Riley exclaims (pp. 165, 166): "Well is it for the people of Missouri, well is it for the people of the Mississippi Valley generally, that this insect cannot go on multiplying indefinitely in their fertile fields. Else, did it go on multiplying and thriving as the Colorado potato-beetle has done, this whole valley would soon become a desert waste. A wise Providence has decreed thus far it shall go and no farther." To the "wisdom" of this "Providence" the poor people of Kansas, Nebraska, etc., may well object, and very naturally withhold their approval from Prof. Riley's biblical rhetoric. It would rather seem, also, from Prof. Riley's map of the portion of Missouri overrun already by the grasshopper, that all the citizens of that State cannot agree that it is "well with them;" but some must be even content to share in the suffering of the farmers of Kansas and Nebraska. As to the "valley of the Mississippi," an inquiry as to the probability of cotton-fields and sugar-plantations affording the proper kind of food for the grasshopper will be in order before Southerners may consider themselves as the chosen people of Prof. Riley's geographically discriminating "Providence." The fact that the cotton-worm (*Aletia argillacea*) migrates as far north as Canada, though not breeding beyond the limits of the growth of the cotton-plant, would show the possibility of the grasshopper exceeding its present range in favorable seasons, and in localities where the food and soil are congenial.—A. R. Grote.

**Social Feeling in Dogs.**—A correspondent furnishes the following statement, for the truth of which he vouches: "A gentleman residing a few miles from Brooklyn, on Long Island, had recently two dogs which for several years had shown marked attachment for each other. One day he noticed that one of the dogs was ill, and the following morning found him dead in the barn, where he was accustomed to sleep. The other dog, which slept in the house, left in the morning when the gentleman went out, lively and playful as usual, and on the barn-door being opened bounded in, and saw his companion dead on the floor. Having smelt of him, he looked at him intently for more than a minute, and started for the house, with drooped ears and tail, evidently in distress—certainly he knew that a great change had taken place in his companion. At breakfast the dog refused food, nor did he eat thereafter; his usual cheerfulness gave place to melancholy, and in a few days he died."

**A Curious Fog.**—Dr. R. Angus Smith describes, in a recent pamphlet, a peculiar sort of fog observed by him in Iceland. On a bright July afternoon Dr. Smith happened to be in Reikjavik, and saw a cloud coming down the street from the southward. Finding that it moved very slowly along the ground, he concluded that it was smoke from a chimney, but smoke mixed with larger particles than are usually seen. When the fog reached the spot where the observer stood, it was found to be devoid of smell, but its influence was decidedly frigorific. Perceiving that it was a fog, Dr. Smith ascended a rising ground, and saw the fog coming from a small lake be-

hind the town, and rolling into the streets very slowly. A similar fog rose from the sea, and rolled, also, into the town. Hence it appeared that the wind had nothing to do with the matter, but that both fogs rolled because they were too heavy to remain suspended. The peculiarity of the fog was in the size of its particles, larger than any the author had ever before seen, and which he estimated at from $\frac{1}{40}$ to $\frac{1}{300}$ of an inch in diameter; another peculiarity was its lumbering mode of rolling, in which it resembled dust. The author found that the particles were perfectly spherical, and not hollow, but concrete throughout.

**Food-Rations of the French People.**—A very curious calculation has been made by M. Hervé Mangon to determine the average ration *per kilogramme of live weight* consumed by the rural population of France. He estimates the "live weight" of the French people in 1861 at 1,771,142,951 kilogrammes (say 3,896,514,492 lb.). But these figures, though they represent fairly enough the total weight of the population, cannot serve as a basis for estimating the amount of food required. Children consume more food, in proportion to their weight, than adults. Hence, the author was obliged to express the weight of children, not as it actually was, but in terms corresponding to their consumption of food. In this way he finds the total weight of the French population to be, from the point of view of nitrogen-consumption, 2,112,978,201 kilogrammes (4,648,552,042 lb.), and from the point of view of carbon-consumption 2,095,886,031 kilogrammes (4,610,949,268 lb.). The food annually consumed in France contains carbon 4,434,716,270 kilogrammes (9,756,375,794 lb.); nitrogen 215,724,211 kilogrammes (474,593,264 lb.). If, now, we divide the sum of the carbon and nitrogen by 365 days and then divide the quotient by the total weight of the population, we find the mean daily rations per kilogramme ($2\frac{1}{5}$ lb.) of live weight to be, carbon, 5.1797 grammes (77.7533 grains); nitrogen, 0.280 gramme, (4.3212 grains). This is the daily ration per kilogramme for the whole population.

In Paris the daily ration *per "live kilogramme"* contains 5.675 grammes of carbon, and 0.332 gramme of nitrogen. Supposing, now, that the daily consumption per kilogramme is the same in Paris, Lyons, Marseilles, and the six other cities whose population exceeds 100,000 souls, the mean daily ration per kilogramme of weight for the country districts is found to contain, of carbon 5.808 grammes, and of nitrogen 0.275 gramme. This ration M. Mangon considers to be sufficient to fit the body for a moderate amount of labor; but it would be good economy, he holds, for employers to give their servants and workmen more abundant food. The dullness and slowness of country people he regards as the natural result of insufficient food.

**Relations of Meteorology to Life.**—At a recent meeting of the British Meteorological Society a communication from the Council was read, entitled "Suggestions of the Observation of Periodic Natural Phenomena," the object being to call attention to those phenomena manifested by organized beings of the vegetable and animal kingdoms dependent on the progression of the seasons, such as the budding, leafing, flowering, fruiting, and the shedding of leaves of trees, shrubs, and herbaceous plants; the earliest and latest appearance of insects; the times at which birds pair and build, and of the arrival and departure of birds of passage; the periods of hibernation of reptiles and small animals, as frogs, dormice, etc. All these phenomena being closely connected with the annual progression of the meteorological elements, are calculated to afford information of the progression of the seasons, of a much more interesting character than that derived from the indication of instruments. Plants are very susceptible of atmospheric influences, and a close correlation exists between the development of plant and animal life as the sun advances in his yearly course, each season being marked by its characteristic phenomena.

**The Marriage of Cousins.** — The influence of marriage of first cousins on the mental constitution of the offspring is almost universally pronounced to be deleterious. This subject has been treated by Mr. George H. Darwin in a paper read at a meeting of the London Statistical Society. Mr. Darwin's

method of obtaining facts upon which to base an induction was by diligent study of Burke's "Peerage," and by sending out circulars of inquiry to members of the upper and middle classes, and to directors of asylums for the insane. The result showed that insanity, idiocy, and deaf-muteness, are in the United Kingdom about evenly divided, *pro rata*, among the progeny of consanguineous and of unconsanguineous marriages; that is to say, Mr. Darwin's investigations have failed to show any evil accruing from the marriages of first cousins. Mr. Darwin acknowledges that the opinion of prominent medical men is against such intermarriages, and that a general consent of physicians possesses far greater weight than his own purely negative results. "My paper," he adds, "is far from giving any thing like a satisfactory solution of the question as to the effects of consanguineous marriages, but it does, I think, show that the assertion that this question has already been set at rest cannot be substantiated. The subject still demands attention, and I hope that my endeavor may lead more competent investigators to take it up from some other side."

**A New Ornamental Evergreen.** — The myrtle-tree of Oregon attains a height of from twenty to fifty feet, and a diameter of from six to twenty inches. Dr. F. S. Matteson, who describes this beautiful tree, in the *Boston Journal of Chemistry*, says that it is an evergreen of very full foliage, with leaves three inches long and half as broad, of a deep shining green color; they are delightfully fragrant. The wood is hard, heavy, fine-grained, and takes a high polish; when varnished it is of a dark, variegated color, and is scarcely inferior to rosewood. The tree is very tenacious of life, sprouts freely from the stump after the tree is felled, and is a vigorous, upright grower. It blossoms in early spring, and the best honey in the world is gathered by bees which work in the myrtle-groves. Settlers are cutting down these groves for lumber and fuel, and the timber is burned in heaps to clear the land. Many trees are left standing for the sake of ornament. The nuts afford good food for swine. This tree must certainly become a leading evergreen for ornamentation, as it is unsurpassed by any known tree for all the qualities which make an evergreen desirable. Dr. Matteson thinks it probable that a highly-fragrant oil, useful as a perfume, and perhaps for medical purposes, may be distilled from the leaves.

**American Origin of the Chinese.** — The colonization of the American Continent from the "Old World," so called, is one of the commonplaces of historical speculation; the colonization of a large portion of the "Old World" from America is a theory of more recent origin, and yet perhaps as plausible as the one which it is intended to supplant. At a meeting of the California Academy of Sciences, Mr. Charles Wolcott Brooks read a paper on the "Origin of the Chinese Race," in which he very learnedly set forth the evidence of their American origin. The author's thesis is supported by a great multitude of facts, but the space at our command will admit only of the barest outline of his argument. According to Chinese annals, Tai Ko Fokee, the great stranger king, ruled the kingdom of China. In pictures he is represented with two small horns, like those associated with the representations of Moses. He and his successor are said to have introduced into China "picture-writing," like that in use in Central America at the time of the Spanish conquest. He taught the motions of the heavenly bodies, and divided time into years and months; he also introduced many other useful arts and sciences.

Now, there has been found at Copan, in Central America, a figure strikingly like the Chinese symbol of Fokee, with his two horns, and in like manner there is a close resemblance between the Central-American and the Chinese figures representing earth and heaven. Either one people learned from the other, or both acquired these forms from a common source. Many physico-geographical facts favor the hypothesis that they were derived in very remote ages from America, and that from China they passed to Egypt. Chinese records say that the progenitors of the Chinese race came from across the sea. But the Pacific is a wide ocean to cross, and favoring winds must have been taken advantage of to carry the emigrants from shore to shore. Mr. Brooks then ex-

plained the action of the southeastern and northeastern trade-winds, and argued that, if large junks started from the coast of Peru and kept before the wind, they would in all probability strike the southern coast of China. America is geologically the oldest continent; if so, why not the first peopled? When in the development of America her progress was sufficient to facilitate emigration, why may she not have given a population to Asia? If the primitive races of this continent have died out and their memorials crumbled away, this is a strong argument in favor of the antiquity of the human race here: in more recent Asia traces still remain of original races.

**Respiration and Versification.** — The natural rate of respiration is from sixteen to twenty-four breaths per minute, the average being twenty. To this fact Dr. Oliver Wendell Holmes attributes the favor in which the octosyllabic verse is held: that verse, more exactly than any other, follows the natural rhythm of respiration. Experiments with the poetry of Scott, Longfellow, and Tennyson, show that an average of twenty lines will be read in a minute, so that one respiration will suffice for each line. It is, in fact, so easy of articulation, that it is apt to run into a sing-song. The twelve-syllable line of Drayton's "Polyolbion" is pronounced almost intolerable, on account of its "intensely unphysiological construction." Dr. Holmes's conclusion is, that nothing in poetry or in vocal music is popular that is not calculated with strict reference to the respiratory functions.

**Diseases of Artisans.**—The diseases incident to the following of various trades are considered in detail by a German physician, Dr. Hirt, in his work "Diseases of Artisans." The effects produced by the inhalation of certain gases are discussed by the author in the second division of his work. With regard to carbonic acid he confirms previous observations of the acute affections produced by it, but he does not find the slightest evidence in favor of chronic intoxication by the constant inhalation of small quantities of the gas. In the processes of beer-brewing, wine-making, distilling and yeast-making, considerable quantities of carbonic acid are given off, but, wherever the ventilation is good, no injurious effects are produced. He appears to have no doubt of the occurrence of chronic poisoning by the action of sulphuretted hydrogen. The symptoms are general weakness, depression and usually total loss of appetite, combined with a feeling of weight on the stomach: the tongue is furred. Bisulphide of carbon, obtained by passing sulphur-fumes over burning coal, and subsequent distillation, is now much used as a solvent of India-rubber. It produces chronic poisoning. The symptoms are, at first, evening headache, and pains in the limbs; sometimes intellectual excitement; often cramps, difficulty of breathing, and increased frequency of the heart's action. After some weeks or months follows a period of depression, heaviness, insensibility of some parts of the skin, diminution of sight, and in some cases of hearing. The bad-smelling gases and effluvia given off from putrefying animal substances are said to be innocuous. The trades exposed to such emanations are tanners, soap-boilers, candle-makers, etc. Workmen get accustomed to the fumes of turpentine, and then such fumes appear to have no injurious effects.

## NOTES.

Errata.—In the article entitled "Absorption of Water by growing Grain," on page 380 of present volume, for "1,796 grammes," *read* "1.796 gramme," and for "two-fifths of an acre," *read* "2.5 acres."

We note the formation of three new associations for the study of natural science, viz.: the Lyceum of Natural Sciences, at San Diego, California; the Natural History Club, of Vineland, New Jersey; and the Nebraska Association for the Advancement of Science, at North Platte, Nebraska.

Admiral Sherard Osborn, of the British Navy, who died on May 6th, in the fifty-fourth year of his age, first gained distinction in the expedition which sailed to the polar regions in search of Franklin in 1849. Again, in 1852, he commanded a vessel which took part in a second expedition on the same errand.

A virulent disease of the lungs, bearing some resemblance to the *epizoötic* which appeared in the United States about two years ago, broke out among the horses at Hull, England, last March. The malady is described as very infectious, and as having carried off a large number of animals.

Died suddenly, on June 11th, at the age of forty-nine years, Joseph Winlock, Director of the Cambridge Observatory, and Phillips Professor of Astronomy in Harvard College. The deceased was a native of Kentucky, and from 1845 till 1852 was Professor of Mathematics in Shelby College, in that State. He then removed to Cambridge, where he was employed in making computations for the *Nautical Almanac.* Later he was appointed Professor of Mathematics for the United States Navy, and served as assistant in the Washington Observatory, superintendent of the *Nautical Almanac*, and Director of the Mathematical Department of the Annapolis Academy. From 1865 till his death he was connected with the Cambridge Observatory and Harvard College.

The fifteenth annual meeting of the National Educational Association will be held in Minneapolis, Minnesota, on Tuesday, Wednesday, and Thursday, the 3d, 4th, and 5th days of August. The officers of the Association are: President, William T. Harris, St. Louis; Secretary, William R. Abbott, Bellevue, Virginia; Treasurer, A. P. Marble, Worcester, Massachusetts.

Committee "F" of the United States Board for testing iron, steel, etc., request information as to the behavior of rails and machinery exposed to the extremes of temperature observed in northern latitudes, when subject to wear or to breakage. Specimens, photographs, results of analysis, statistics of railroads, statements from rolling-mills, published or unpublished essays—in short, information of any kind upon the subject may be sent in to the committee, R. H. Thurston, chairman, Stevens Institute, Hoboken, New Jersey.

An elaborate work by A. R. Wallace, on the "Geographical Distribution of Animals," is announced as soon to be published by Macmillan. It will be in two volumes, illustrated with many maps and woodcuts.

Mary Putnam Jacobi, M. D., of New York, has recently received from Paris, says the *Tribune*, the bronze medal awarded three years ago by the Academy of Medicine for her graduating thesis. In the competition Mrs. Jacobi attained the rank of from fifth to eighth in a class of 300, all men except herself. And yet Paris medical journals are complaining that "the admission of women students to the Academy has lowered its standards!"

It is stated in an Albany journal that Seth Green has succeeded in hatching a large number of sturgeon-eggs. It is intended to stock the Hudson River with sturgeon, a fish which at one time was very abundant in that stream, but which has for years been declining in numbers.

The Swedish Arctic Expedition of the present year was to have sailed in June for Nova Zembla. It will first study the botany, zoölogy, and ethnology, of the south of the island, and then advance along the west coast to the northernmost point. Thence it will advance to the northeast to explore this unknown part of the Polar Sea. It then goes south to the mouth of the Obi and the Yenisei. Here the explorers will quit the ship and go up the river in boats, returning home afterward by land. Prof. Nordenskiöld commands the expedition. A wealthy merchant, Oskar Dickson, bears all the expenses.

In excavating near Rideau Hall, Ottawa, the residence of the Governor-General of Canada, the workmen made an interesting geological discovery. They came upon a stratum of fossil-rock several feet thick, containing beautiful petrified winged insects. Some of these are like butterflies, with the delicate fibre of the wings in a perfect state of preservation.

During the last fifty years the water-level of the rivers Elbe and Oder has fallen 17 inches, that of the Rhine 24, of the Vistula 26, and that of the Danube as much as 55 inches at Orsova. And there is a similar decrease in the water-supply from springs in Germany. The cause of this decline is attributable to the present reckless cutting down of forests, as also to the artificial drainage now so generally adopted by farmers.

Dr. Paul Bert, distinguished for his researches on the physiological effects of atmospheric pressures, has been chosen President of the French Aëronautical Society. Gaston Tissandier is one of the vice-presidents.

The work of the Geological Survey of California having been suspended by the State Legislature, a vast collection of botanical observations remained in manuscript, which the State refused to have printed. Prof. Gilman has succeeded in raising a subscription of \$5,000, for the purpose of publishing this valuable material. The funds were contributed by nine public-spirited citizens of San Francisco.

Spectacle-frames with fine wire gauze in place of glass are found to answer perfectly for the protection of the eyes from dust in various trades and occupations, such as stone-cutting, thrashing, etc. Such spectacles permit the necessary access of air to the eye, and produce no inconvenience to the wearer.

The best authorities consulted by the British insurance companies, as to the advisability of putting an extra premium on the policies held by the members of the

Arctic Expedition, were of opinion that the risks were not so great as on the west coast of Africa, and hence no extra premium was exacted.

The extension of railways in India is gradually undermining the institution of caste. In a lecture on this subject, Mr. Framjee R. Vicajee, a native of Bombay, said that in England the only caste which the railway class-system protects from contamination is that which is based on wealth; but in India, which is a poor country, really high-caste people travel third class to save their money, while in England they travel first-class to save or assert their caste.

The mean height of Europe is estimated by Dr. G. Leitpoldt at 974 feet. Switzerland shows the maximum mean height, 4,624 feet, and the Netherlands the minimum, 31 feet. Intermediate are Spain and Portugal, 2,298 feet; Austria, 1,698; Italy, 1,696; France, 1,292; British Islands, 714; Germany, 701; Russia, 548; Denmark, 115.

According to Dr. Otto Krause, tobacco-smoke always contains a considerable quantity of carbonic oxide, and the after-effects of smoking are principally caused by this poisonous gas. Dr. Krause holds that the after-effects are all the more energetic, the more inexperienced the smoker is, and he thus explains the unpleasant results of the first attempts at smoking, which are generally ascribed to nicotine alone.

The practice of vaccination is making fair progress in India. One obstacle is the religious scruples of the people, but the medical officers state that these may now be overcome by the payment of one *auna* (three cents) per child.

The water of a much-esteemed mineral spring in England was, on chemical analysis, found to contain in very large proportion every known form of impurity, viz., oxidizable organic matter, ammonia, chlorides, nitrates, nitrites, living organisms, and decaying vegetable matter.

Two instances are mentioned in the *Lancet* of undoubted transmission of disease from human beings to domestic animals. In one case whooping-cough was communicated to a cat from children. In the other case dogs took small-pox from persons suffering from that disease.

It is announced by the Norwegian papers that the Government have voted about $25,000 toward a scheme for the prosecution of deep-sea investigations between Iceland, Spitzbergen, the Faroe Islands, and Jan Mayen Island. Operations will be conducted on the model of the Challenger's researches.

The following instance of canine sagacity and fidelity is reported in *Land and Water*: A man named Colville left his home near Dunfermline, accompanied by his dog. He did not return that day, but the next afternoon the dog came home, and behaved in a very eccentric manner, apparently endeavoring to attract attention. Seeing that the animal continually rushed off in the same direction, and that he evidently wanted some one to go with him, Colville's friends resolved to follow him. The dog led them to a disused coal-shaft, and there stopped. Grappling irons were procured, and the dead body of Colville was soon brought to the surface.

In the *Annals and Magazine of Natural History* for January, 1875, Captain F. W. Hutton gives a technical description of two new species of crustacea recently discovered in New Zealand.

Three years ago an American tourist, John Blackford, lost his life in an attempt to ascend Mont Blanc without a guide. His body was recently found in a large ice-block after several days of thaw. Features and clothes were in a perfect state of preservation.

The Fish Commissioners of Pennsylvania and New Jersey, says *Forest and Stream*, are preparing to engage more actively than ever in shad-culture on the Delaware. Hatching-boxes have been located at three different stations, viz., Point Pleasant, Trenton, and Howell's Fishery.

Says the *Lancet*: "Another case of inflammation of the feet, caused by the wearing of socks with orange-red stripes, has occurred. The victim this time is Mr. Hart Dyke, the Conservative Whip. We presume the offending dye is coralline, which gained such notoriety a year or so ago. It is impossible to avoid asking whether the sale of such dangerous articles cannot be stopped. The color is attractive, and just now is fashionable; any one, however, who has respect for his 'poor feet' would certainly be wise to avoid it."

A bill for regulating the practice of vivisection has been introduced into the British Parliament. It proposes to enact that after January, 1876, vivisection is only to be performed in places duly registered, and upon notice being given to the Secretary of State. Anæsthetics are always to be employed, except when a special license has been granted by the Secretary. The penalty for an offense against the act is not to exceed £20.

The library of the late J. J. Audubon, containing 800 volumes, was destroyed by fire at Shelbyville, Kentucky, on April 29th.


JULIUS E. HILGARD.

THE

# POPULAR SCIENCE MONTHLY.

SEPTEMBER, 1875.

## SCIENTIFIC CULTURE.[1]

By JOSIAH P. COOKE, Jr.

PROFESSOR OF CHEMISTRY AND MINERALOGY IN HARVARD COLLEGE.

YOU have come together this morning to begin various elementary courses of instruction in chemistry and mineralogy. As I have been informed, most of you are teachers by profession, and your chief object is to become acquainted with the experimental methods of teaching physical science, and to gain the advantages in your study which the large apparatus of this university is capable of affording. In all this I hope you will not be disappointed. You, as teachers, know perfectly well that success must depend, first of all, on your own efforts; but, since the methods of studying Nature are so different from those with which you are familiar in literary studies, I feel that the best service I can render, in this introductory address, is to state, as clearly as I can, the great objects which should be kept in view in the courses on which you are now entering.

By your very attendance on these courses you have given the strongest evidence of your appreciation of the value of chemical studies as a part of the system of education, and let me say, in the first place, that you have not overvalued their importance. The elementary principles and more conspicuous facts of chemistry are so intimately associated with the experience of every-day life, and find such important applications in the useful arts, that no man at the present day can be regarded as educated who is ignorant of them. Not to know why the fire burns, or how the sulphur-trade affects the industries of the world, will be regarded, by the generation of men among whom your pupils will have to win their places in society, as a greater mark of ignorance than a false quantity in Latin prosody or a solecism in grammar. Moreover, I need not tell you that physical science has become a great power in the world. Indeed, after religion, it is the

[1] An Address delivered July 7, 1875, at the opening of the Summer Courses of Instruction in Chemistry, at Harvard University

greatest power of our modern civilization. Consider how much it has accomplished during the last century toward increasing the comforts and enlarging the intellectual vision of mankind. The railroad, the steamship, the electric telegraph, photography, gas-lights, petroleum-oils, coal-tar colors, chlorine-bleaching, anæsthesia, are a few of its recent material gifts to the world; and not only has it made one pair of hands to do the work of twenty, but it has so improved and facilitated the old industries that what were luxuries to the fathers of our republic have become necessities to our generation. And when, passing from these material fruits, you consider the purely intellectual triumphs of physical science, such as those which have been gained with the telescope, the microscope, and the spectroscope, you cannot wonder at the esteem in which these branches of study are held in this practical age of the world.

Now, these immense results have been gained by the application to the study of Nature of a method which was so admirably described by Lord Bacon in his "Novum Organon," and which is now generally called the experimental method. What we observe in Nature is an orderly succession of phenomena. The ancients speculated about these phenomena as well as ourselves, but they contented themselves with speculations, animating Nature with the products of their wild fancies. Their great master, Aristotle, has never been excelled in the art of dialectics; but his method of logic applied to the external world was of very necessity an utter failure. It is frequently said, in defense of the exclusive study of the records of ancient learning, that they are the products of thinking, loving, and hating men, like ourselves, and it is claimed that the study of science can never rise to the same nobility because it deals only with *lifeless* matter. But this is a mere play on words, a repetition of the error of the old schoolmen. Physical science is noble because it does deal with thought, and with the very noblest of all thought. Nature at once manifests and conceals an Infinite Presence: Her methods and orderly successions are the manifestations of Omnipotent Will; Her contrivances and laws the embodiment of Omniscient Thought. The disciples of Aristotle so signally failed simply because they could see in Nature only a reflection of their idle fancies. The followers of Bacon have so gloriously succeeded because they approached Nature as humble students, and, having first learned how to question Her, have been content to be taught and not sought to teach. The ancient logic never relieved a moment of pain, or lifted an ounce of the burden of human misery. The modern logic has made a very large share of material comfort the common heritage of all civilized men.

In what, then, does this Baconian system consist? Simply in these elements: 1. Careful observation of the conditions under which a given phenomenon occurs; 2. The varying of these conditions by experiments, and observing the effects produced by the variation. We

thus find that some of the conditions are merely accidental circumstances, having no necessary connection with the phenomenon, while others are its invariable antecedent. Having now discovered the true relations of the phenomenon we are studying, a happy guess, suggested probably by analogy, furnishes us with a clew to the real causes on which it depends. We next test our guess by further experiments. If our hypothesis is true, this or that must follow; and, if in all points the theory holds, we have discovered the law of which we are in search. If, however, these necessary inferences are not realized, then we must abandon our hypothesis, make another guess, and test that in its turn. Let me illustrate by two well-known examples:

The, of old, universally accepted principle that all living organisms are propagated by seeds or germs (*omnia ex ovo*) has been seriously questioned by a modern school of naturalists. Various observers have maintained that there were conditions under which the lower forms of organic life were developed independently of all such accessories, but other, and equally competent, naturalists who have attempted to investigate the subject, have obtained conflicting results. Thus it was observed that certain low forms of life were quite constantly developed in beef-juice that had been carefully prepared and hermetically sealed in glass flasks, even after these flasks had been exposed for a long time to the temperature of boiling water. "Here," proclaims the new school, "is unmistakable evidence of spontaneous generation; for, if past experience is any guide, all germs must have been killed by the boiling water." "No," answer the more cautious naturalists, "you have not yet proved your point. You have no right to assume that all germs are killed at this temperature." The experiments, therefore, were repeated under various conditions and at different temperatures, but with unsatisfactory results, until Pasteur, a distinguished French physicist, devised a very simple mode of testing the question. He reasoned thus: "If, as is generally believed, the presence of invisible spores in the air is an essential condition of the development of these lower growths, then their production must bear some proportion to the abundance of these spores. Near the habitations of animals and plants, where the spores are known to be in abundance, the development would be naturally at a maximum, and we should expect that the growth would diminish in proportion as the microscope indicated that the spores diminished in the atmosphere." Accordingly, Pasteur selected a region in the Jura Mountains suitable for his purpose, and repeated the well-known experiment with beef-juice, first at the inn of a town at the foot of the mountains, and then at various elevations up to the bare rocks which covered the top of the ridge, a height of some 8,000 feet. At each point he sealed up beef-juice in a large number of flasks and watched the result. He found that while in the town the animalcules were developed in almost all the flasks, they appeared

only in two or three out of a hundred cases where the flasks had been sealed at the top of the mountain, and to a proportionate extent in those sealed at the intermediate elevations. What, now, did these experiments prove? Simply this, that the development of these organic forms was in direct proportion to the number of germs in the air. It did not settle the question of spontaneous generation, but it showed that false conclusions had been deduced from the experiments which had been cited to prove it.

A still more striking illustration of the same method of questioning Nature is to be found in the investigation of Sir Humphry Davy on the composition of water. The voltaic battery which works our telegraphs was invented by Volta in 1800; and later, during the same year, it was discovered in London, by Nicholson and Carlisle, that this remarkable instrument had the power of decomposing water. These physicists at once recognized that the chief products of the action of the battery on water were hydrogen and oxygen gases, thus confirming the results of Cavendish, who in 1781 had obtained water by combining these elementary substances; oxygen having been previously discovered in 1775, and hydrogen at least as early as 1766. It was, however, very soon also observed that there were always formed by the action of the battery on water, besides these aëriform products, an alkali and an acid, the alkali collecting around the negative pole and the acid around the positive pole of the electrical combination. In regard to the nature of this acid and alkali there was the greatest difference of opinion among the early experimenters on this subject. Cruickshanks supposed that the acid was nitrous acid, and the alkali ammonia. Desormes, a French chemist, attempted to prove that the acid was muriatic acid; while Brugnatelli asserted that a new and peculiar acid was formed, which he called the electric acid.

It was in this state of the question that Sir Humphry Davy began his investigation. From the analogies of chemical science, as well as from the previous experiments of Cavendish and Lavoisier, he was persuaded that water consisted solely of oxygen and hydrogen gases, and that the acid and alkali were merely adventitious products. This opinion was undoubtedly well-founded; but, great disciple of Bacon as he was, Davy felt that his opinion was worth nothing unless substantiated by experimental evidence, and accordingly he set himself to work to obtain the required proof.

In Davy's first experiments the two glass tubes which he used to contain the water were connected together by an animal membrane, and he found, on immersing the poles of his battery in their respective tubes, that, besides the now well-known gases, there were really formed muriatic acid in one tube and a fixed alkali in the other. Davy at once, however, suspected that the acid and alkali came from common salt contained in the animal membrane, and he therefore rejected this material and connected the glass tubes by carefully-washed cotton

fibre: when, on submitting the water as before to the action of the voltaic current, and continuing the experiment through a great length of time, no *muriatic* acid appeared; but he still found that the water in the one tube was strongly alkaline, and in the other strongly acid, although the acid was, chiefly at least, nitrous acid. A part of the acid evidently came from the animal membrane, but not the whole, and the source of the alkali was as obscure as before. Davy then made another guess. He knew that alkali was used in the manufacture of glass; and it occurred to him that the glass of the tubes, decomposed by the electric current, might be the origin of the alkali in his experiments. He therefore substituted for the glass tubes cups of agate, which contains no alkali, and repeated the experiment, but still the troublesome acid and alkali appeared. Nevertheless, he said, it is possible that these products may be derived from some impurities existing in the agate cups, or adhering to them; and so, in order to make his experiments as refined as possible, he rejected the agate vessels and procured two conical cups of pure gold, but on repeating the experiments the acid and alkali again appeared.

And now let me ask who is there of us who would not have concluded at this stage of the inquiry that the acid and alkali were essential products of the decomposition of water? But not so with Davy. He knew perfectly well that all the circumstances of his experiments had not been tested, and until this had been done he had no right to draw such a conclusion. He next turned to the water he was using. It was distilled water, which he supposed to be pure, but still, he said, it is possible that the impurities of the spring-water may be carried over to a slight extent by the steam in the process of distillation, and may therefore exist in my distilled water to a sufficient amount to have caused the difficulty. Accordingly he evaporated a quart of this water in a silver dish, and obtained seven-tenths of a grain of dry residue. He then added this residue to the small amount of water in the gold cones and again repeated the experiment. The proportion of alkali and acid was sensibly increased.

You think he has found at last the source of the acid and alkali in the impurities of the water. So thought Davy, but he was too faithful a disciple of Bacon to leave this legitimate inference unverified. Accordingly he repeatedly distilled the water from a silver alembic until it left absolutely no residue on evaporation, and then with water, which he knew to be pure, and contained in vessels of gold from which he knew it could acquire no taint, he still again repeated the already well-tried experiment. He dipped his test-paper into the vessel connected with the positive pole, and the water was still decidedly acid. He dipped the paper into the vessel connected with the negative pole, and the water was still alkaline.

You might well think that Davy would have been discouraged here. But not in the least. The path to the great truths which

Nature hides often leads through a far denser and a more bewildering forest than this; but then there is not infrequently a *blaze* on the trees which points out the way, although it may require a sharp eye in a clear head to see the marks. And Davy was well enough trained to observe a circumstance which showed that he was now on the right path and heading straight for the goal. On examining the alkali formed in this last experiment, he found that it was not, as before, a fixed alkali, soda or potash, but the volatile alkali ammonia. Evidently the fixed alkali came from the impurities of the water, and when, on repeating the experiment with pure water in agate cups or glass tubes, the same results followed, he felt assured that so much at least had been established. There was still, however, the production of the volatile alkali and of nitrous acid to be accounted for. As these contain only the elements of air and water, Davy thought that possibly they might be formed by the combination of hydrogen at the one pole and of oxygen at the other with the nitrogen of the air, which was necessarily dissolved in the water. In order, therefore, to eliminate the effect of the air, he again repeated the experiment under the receiver of an air-pump from which the atmosphere had been exhausted, but still the acid and alkali appeared in the two cups.

Davy, however, was not discouraged by this, for the *blazes* on the trees were becoming more numerous, and he now felt sure that he was fast approaching the end. He observed that the quantity of acid and alkali had been greatly diminished by exhausting the air, and this was all that could be expected, for, as Davy knew perfectly well, the best air-pumps do not remove all the air. He therefore for the last experiment not only exhausted the air, but replaced it with pure hydrogen, and then exhausted the hydrogen and refilled the receiver with the same gas several times in succession, until he was perfectly sure that the last traces of air had been as it were washed out. In this atmosphere of pure hydrogen he allowed the battery to act on the water, and not until the end of twenty-four hours did he disconnect the apparatus. He then dips his test-paper into the water connected with the positive pole, and there is no trace of acid; he dips it into the water at the negative pole, and there is no alkali; and you may judge with what satisfaction he withdraws those slips of test-paper, whose unaltered surfaces showed that he had been guided at last to the truth, and that his perseverance had been rewarded.

The fame of Sir Humphry Davy rests on his discovery of the metals of the alkalies and earths which first revealed the wonderful truth that the crust of our globe consists of metallic cinders; but none of these brilliant results show so great scientific merit or such eminent power of investigating Nature as the experiments which I have just detailed. I have not, however, described them here for the purpose of glorifying that renowned man. His honored memory needs no such office at my hands. My only object was to show you what is

meant by the Baconian method of science, and to give some idea of the nature of that modern logic which within the last fifty years has produced more wonderful transformations in human society than the author of Aladdin ever imagined in his wildest dreams. In this short address I can of course give you but a very dim and imperfect idea of what I have called the Baconian system of experimental reasoning. Indeed, you cannot form any clear conception of it, until in some humble way you have attempted to use the method, each one for himself, and you have come here in order that you may acquire such experience. My object, however, will be gained if these illustrations serve to give emphasis to the following statements, which I feel I ought to make at the opening of these courses of instruction—statements which have an especial appropriateness in this place; since I am addressing teachers, who are in a position to exert an important influence on the system of education in this country.

In the first place, then, I must declare my conviction that no educated man can expect to realize his best possibilities of usefulness without a practical knowledge of the methods of experimental science. If he is to be a physician, his whole success will depend on the skill with which he can use these great tools of modern civilization. If he is to be a lawyer, his advancement will in no small measure be determined by the acuteness with which he can criticise the manner in which the same tools have been used by his own or his opponent's clients. If he is to be a clergyman, he must take sides in the great conflict between theology and science, which is now raging in the world, and, unless he wishes to play the part of the doughty knight Don Quixote, and think he is winning great victories by knocking down the imaginary adversaries which his ignorance has set up, he must try the steel of his adversary's blade. Let me be fully understood. It is not to be expected or desired that many of our students should become professional men of science. The places of employment for scientific men are but few, and more in the future than in the past they will naturally be secured by those whom Nature has endowed with special aptitudes or tastes—usually the signs of aptitudes—to investigate her laws. That our country will always offer an honorable career to her men of genius, we have every reason to expect, and these born students of Nature will usually follow the plain indications of Providence without encouragement or direction from us. It is different, however, with the great body of earnest students who are conscious of no special aptitudes, but who are desirous of doing the best thing to fit themselves for usefulness in the world; and I feel that any system of education is radically defective which does not comprise a sufficient training in the methods of experimental science to make the mass of our educated men familiar with this tool of modern civilization: so that when, hereafter, new conquests over matter are announced, and great discoveries are proclaimed, they may be able not

only to understand but also to criticise the methods by which the assumed results have been reached, and thus be in a position to distinguish between the true and the false. Whether we will or not, we must live under the direction of this great power of modern society, and the only question is whether we will be its ignorant slave or its intelligent servant.

In the second place, it seems fitting that I should state to you what I regard as the true aims to be kept in view in a course of scientific study, and to give my reasons for the methods we have adopted in arranging the courses you are about beginning.

In our day there has arisen a warm discussion as to the relative claims of two kinds of culture, and attempts are made to create an antagonism between them. But all culture is the same in spirit. Its object is to awaken and strengthen the powers of the mind; for these, like the muscles of the body, are developed and rendered strong and active only by exercise; while on the other hand they may become atrophied from mere want of use. Science culture differs in its methods from the old classical culture, but it has the same spirit and the same object. You must not, therefore, expect me to advocate the former at the expense of the latter; for, although I have labored assiduously during a quarter of a century to establish the methods of science teaching which have now become general, I am far from believing that they are the only true modes of obtaining a liberal education. So far from this, if it were necessary to choose one of two systems, I should favor the classical; and why?

Language is the medium of thought, and cannot be separated from it. He who would think well must have a good command of language, and he who has the best command of language I am almost tempted to say will think the best. For this reason a certain amount of critical study of language is essential for every educated man, and such study is not likely to be gained except through the great ancient languages; the advocates of classical scholarship frequently say, cannot be gained. I am not ready to accept this dictum; but I most willingly concede that in the present state of our schools it is not likely to be gained. I never had any taste myself for classical studies; but I know that I owe to the study a great part of the mental culture which has enabled me to do the work that has fallen to my share in life. But while I concede all this, I do not believe, on the other hand, that the classical is the only effective method of culture; you evidently do not think so, for you would not be here if you did. But, in abandoning the old tried method, which is known to be good, for the new, you must be careful that you gain the advantages which the new offers; and you will not gain the new culture you seek unless you study science in the right way. In the classical departments the methods are so well established, and have been so long tested by experience, that there can hardly be a wrong way. But in science there is not only a wrong

way, but this wrong way is so easy and alluring, that you will most certainly stray into it unless you strive earnestly to keep out of it. Hence I am most anxious to point out to you the right way, and do what I can to keep you in it; and you will find that our courses and methods have been devised with this object.

When advocating in our mother University of Cambridge, in Old England, the claims of scientific culture, I was pushed with an argument which had very great weight with the eminent English scholars present, and which you will be surprised to learn was regarded as fatal to the success of the science *triposes* then under debate. The argument was, that the experimental sciences could not be made the subjects of competitive examinations. Some may smile at such an objection; but, as viewed from the English stand-point, there was really a great deal in it, and the argument brought out the radical difference between scientific and classical culture. The old method of culture may be said to have culminated in the competitive examinations of the English universities. We have no such examinations here. Success depends not simply on knowing your subject thoroughly, but on having it at your fingers' ends, and those fingers so agile that they can accomplish not only a prodigious amount of work in a short time, but can do this work with absolute accuracy. For the only approach we make to an experience of this kind, we must look to our athletic contests. It may of course be doubted whether the ability, once in a man's life, to perform such mental feats, is worth what it costs. Still it implies a very high degree of mental culture, and it is perfectly certain that the experimental sciences give no field for that sort of mental prize-fights. It is easy to prepare written examinations which will show whether the students have been faithful to their work, but they cannot be adapted to such competitions as I have described without abandoning the true object of science culture. The ability of the scientific student can only be shown by long-continued work at the laboratory-table, and by his success in investigating the problems which Nature presents.

We have here struck the true key-note of the scientific method. The great object of all our study should be to study Nature, and all our methods should be directed to this one object. This aim alone will ennoble our scholarship as students, and will give dignity to our scientific calling as men of science. It is this high aim, moreover, which vindicates the worth of the mode of culture we have chosen. What is it that ennobles literary culture but the great minds which, through this culture, have honored the nations to which they belong? The culture we have chosen is capable of even greater things; not because science is nobler than art, for both are equally noble;—it is the thought, the conception, which ennobles, and I care not whether it be attained through one kind of exercise of the mental faculties or another;—but we are capable of grander and nobler thoughts than Plato,

Cicero, Shakespeare, or Newton, because we live in a later period of the world's history; when, through science, the world has become richer in great ideas. It is, I repeat, the great thought which ennobles, and it ennobles because it raises to a higher plane that which is immortal in our manhood.

If I have made my meaning clear, and if you sympathize with my feelings, you will understand why I regard culture as so important to the individual and to the nation. The works of Shakespeare and of Bacon are of more value to England to-day than the memories of Blenheim or Trafalgar; and those great minds will still be living powers in the world when Marlborough and Nelson are only remembered as historical names. I therefore believe that it is the first duty of a country to foster the highest culture, and that it should be the aim of every scholar to promote this culture both by his own efforts and his active influence. A nation can become really great in no other way. We live in a country of great possibilities; and the danger is that, as with many men I have known in college, of great potential abilities, the greatness will end where it begins. The scholars of the country should have but one voice in this matter, and urge upon the government and upon individuals the duty of encouraging and supporting mental culture for its own sake. The time has passed when we can afford to limit the work of our higher institutions of learning to teaching knowledge already acquired. Henceforth the investigation of unsolved problems, and the discovery of new truth, should be one of the main objects at our American universities, and no cost grudged, which is required to maintain at them the most active minds, in every branch of knowledge which the country can be stimulated to produce. I could urge this on the self-interest of the nation as an obvious dictate of political economy. I could say, and say truly, that the culture of science will help us to develop those latent resources of which we are so proud; will enable us to grow two blades of grass where one grew before; to extract a larger per cent. of metal from our ores; to economize our coal, and in general to direct our waiting energies so that they may produce a more abundant pecuniary reward. I could tell of Galvani studying for twenty long years to no apparent purpose the twitching of frogs' hind-legs and thus sowing the seed from which has sprung the greatest invention of modern times. Or, if our Yankee impatience would be unwilling to wait half a century for the fruit to ripen, I could point to the purely theoretical investigations of organic chemistry, which in less than five years have revolutionized one of the great industries of Europe, and liberated thousands of acres for a more beneficent agriculture. This is all true, and may be urged properly if higher considerations will not prevail. It is an argument I have used in other places, but I will not use it here; although I gladly acknowledge the Providence which brings at last even material fruits to re-

ward conscientious labor for the advancement of knowledge and the intellectual elevation of mankind. I would rather point to that far greater multitude who worked in faith for the love of knowledge, and who ennobled themselves and ennobled their nation, not because they added to its material prosperity, but because they made themselves and made their fellows more noble men.

I come back now again to the moral of all this, to urge upon you, as the noblest patriotism and the most enlightened self-interest, the duty of striving for yourselves and encouraging in others the highest culture in the studies you have chosen, and this culture with one end in view to advance knowledge. I am far, of course, from advising you to grapple immaturely with unsolved problems, or, when you have gained the knowledge with which you can dare to venture from the beaten track, to undertake work beyond your power. Many a young scientific man has suffered the fate of Icarus in attempting to soar too high. Moreover, I am far from expecting that all or many of you will ever have the opportunity of going beyond the well-explored fields of knowledge; but you can all have the aim, and that aim will make your work more worthy and more profitable to yourselves. Every American boy cannot be President of the United States, but if, as our English cousins allege, he believes that he can be, the very belief makes him an abler man.

We have dwelt long enough on these generalities, and it is time to come down to commonplaces, and to inquire what are the essential conditions of this scientific culture which shall fit us to investigate Nature; and the first thought that occurs to me in this connection may be expressed thus: Science presents to us two aspects, which I may call its objective and its subjective aspect. Objectively it is a body of facts, which we have to observe, and subjectively it is a body of truths, conclusions, or inferences, deduced from these facts; and the two sides of the subject should always be kept in view. I propose next to say a few words in regard to each of these two aspects of our study, and in regard to the best means of training our faculties so as to work successfully in each sphere. First, then, success in the observation of phenomena implies three qualities at least, namely, quickness and sharpness of perception, accuracy in details, and truthfulness; and on its power to cultivate these qualities a large part of the value of science, as a means of education, depends. To begin with the cultivation of our perceptions. We are all gifted with senses, but how few of us use them to the best advantage! "We have eyes and see not;" for, although the light paints the picture on the retina, our dull perceptions give no attention to the details, and we retain only a confused impression of what has passed before our eyes. "But how," you may ask, "are we to cultivate this sharpness of perception?" I answer, only by making a conscious effort to fix our attention on the objects we study, until the habit becomes a second nature. I have often noticed,

with surprise, the power which uneducated miners frequently possess, of recognizing many minerals at sight. This they have acquired by long experience and close familiarity with such objects, and such power of observation is with them so purely a habit that they are frequently unable to state clearly the grounds on which their conclusions are based. They recognize the minerals by what in common language is called their *looks*, and they notice delicate differences in the *looks* to which most men are blind. It is, however, the business of the scientific mineralogist to analyze these *looks*, and to point out in what the differences consist; so that by fixing his attention on these points the student may gain, by a few hours' study, the power which the miner acquires only after long experience. The chief difficulty, however, which we find in teaching mineralogy is, that the students do not readily see the differences when they are pointed out, or, if they see them, do not remember them with sufficient precision to render their subsequent observations conclusive and precise. This either arises from a failure to cultivate the powers of observation in childhood, or the subsequent blunting of them by disuse. The ladies will scout the idea that a brooch of cut-glass is as ornamental as one of diamond, and yet I venture to assert that there is not one person in fifty, at least of those who have not made a study of the subject, who can tell the difference between the two. The external appearance depends simply on what we call lustre. The lustre of glass is vitreous, that of the diamond adamantine, and I know of no other distinction which it is more difficult for students to recognize than this. Those of you who study mineralogy will experience this difficulty, and it can be overcome only by giving careful attention to the subject. The teacher can do nothing more than put in your hands the specimens which illustrate the point, and you must study these specimens until you see the difference. It is a question of sight, not of understanding, and all the optical theories of the cause of the lustre will not help you in the least toward seeing the difference between diamond and glass, or anglesite and heavy spar. Another illustration of the same fact is the constant failure of students to distinguish by the eye alone between the two minerals called copper-glance and gray copper. There is a difference of color and lustre which, although usually well marked, it requires an educated eye to distinguish.

Mineralogy undoubtedly demands a more careful cultivation of the perceptions than the other branches of chemistry; but still you will find abundant practice for close observation in them all. I have often known students to reach erroneous results in qualitative analysis by mistaking a white precipitate in a colored liquid for a colored precipitate; or by not attending to similar broad distinctions which would have been obvious to any careful observer; and so in quantitative analysis, mere delicacy of touch or handling is a great element of success.

But I must pass on to speak of the importance in the study of Nature of accuracy in detail, which is the second condition of successful observation of which I spoke. We must cultivate not only accuracy in observing details, but also accuracy in following details which have been laid down by others for our guidance. In science we cannot draw correct conclusions from our premises unless we are sure that we have all the facts, and what seemed at first an unimportant detail often proves to be the determining condition of the result; and, again, if we are told that under certain conditions a certain sign is the proof of the presence of a certain substance, we have no right to assume that the sign is of any value unless the conditions are fulfilled. A black precipitate, for example, obtained under certain conditions, is a proof of the presence of nickel, but we cannot assert that we have found nickel unless we have followed out those details in every particular. Of course, we must avoid empiricism as far as we can. We must seek to learn the reasons of the details, and such knowledge will not only render our works intelligent, but will also frequently enable us to judge how far the details are essential, and to what extent our processes may be varied with safety. We must also avoid trifling, and above all "the straining at a gnat and swallowing a camel," as is the habit with triflers. Large knowledge and good judgment will avoid all such errors; but, if we must choose between fussiness and carelessness, the first is the least evil. Slovenly work means slovenly results, and habits of carefulness, neatness, and order, produce as excellent fruits in the laboratory as in the home.

Last in order but first in importance of the conditions of successful observation, mentioned above, stands truthfulness. Here you may think I am approaching a delicate subject, of which even to speak might seem to cast a reproach. But not so at all. I am not speaking here of conscious deception, for I assume that no one who aspires to be a student of Nature can be guilty of that. But I am speaking of a quality whose absence is not necessarily a mark of sinfulness, but whose possession, in a high degree, is a characteristic of the greatest scientific talent. As every lawyer knows, he is a rare man whose testimony is not colored by his interests, and a very large amount of self-deception is compatible with conscious honesty of purpose. So among scientific students the power to keep the mind unbiased and not to color our observations in the least degree, is one of the rarest as it is one of the noblest of qualities. It is a quality we must strive after with all our might, and we shall not attain it unless we strive. Remember, our observations are our data, and, unless accurate, every thing deduced from them must have the taint of our deception. We cannot deceive Nature, however much we may deceive ourselves; and there is many a student who would cut off his right hand rather than be guilty of a conscious untruth, who is yet constantly untruthful to himself. Every year students of mineralogy present to me written descriptions of

mineral specimens which particularize, as observed, characters that do not appear on the specimens given them to determine, although they may be the correct characters of some other mineral. There is usually no want of honesty in this, but, deceived by some accident, the student has made a wrong guess, and then imagined that he saw on the specimen those characters which he knew from the descriptions ought to appear on the assumed mineral. So, also, it not unfrequently happens that a student in qualitative analysis, who has obtained some hints in regard to the composition of his solution, will torture his observations until they seem to him to confirm his erroneous inferences; and again the student in quantitative analysis, who finds out the exact weight he ought to obtain, is often insensibly influenced by this knowledge—in the washing and ignition of his precipitate, or in some other way—and thus obtains results whose only apparent fault may be a too close agreement with theory, but which, nevertheless, are not accurate because not true. It is evident how fatal such faults as these must be to the investigation of truth, and they are equally destructive of all scientific scholarship. Their effect on the student is so marked that although he may deceive himself, he will rarely deceive his teacher. That he should lose confidence in his own results is, to the teacher, one of the most marked indications of such false methods of study, but the student usually refers his want of success to any cause but the real one—his own untruthfulness. He will complain of the teacher, or of the methods of instruction, and may even persuade himself that all scientific results are as uncertain as his own. As I have said, mere ordinary truthfulness, which spurns any conscious deception, will not save us from falling into such faults. Our scientific study demands a much higher order of truthfulness than this. We should so love the truth above all price as to strive for it with single-hearted and unswerving purpose. We must be constantly on our guard to avoid any circumstance which would tend to bias our minds or warp our judgments, and we must make the attainment of the truth our sole motive guide and end.

It remains for me, before closing this address, to say a few words on what I have called the subjective aspect of scientific study. Science offers us not only a mass of phenomena to be observed, but also a body of truths which have been deduced from these observations; and, without the power of drawing correct inferences from the data acquired, exact observations would be of little value. I have already described the inductive method of reasoning, and illustrated it by two noteworthy examples, and, in a humbler measure, we must apply the same method in our daily work in the laboratory. We must learn how to vary our experiments so as to eliminate the accidental circumstances, and make evident the essential conditions of the phenomena we are studying. Such power can only be acquired by practice, and a somewhat long experience in active teaching has convinced me that

there is no better means of training this logical faculty than the study of qualitative chemical analysis in which many of you are to engage. The results of the processes of qualitative analysis are perfectly definite and trustworthy; but they are only reached by following out the indications of experiments which are frequently obscure, and even apparently contradictory; reconciling by new experiments the seeming discrepancies, and, at last, having eliminated all other possible causes of the phenomena observed, discovering the true nature of the substances under examination. The study of mineralogy affords an almost equally good practice, although in a somewhat different form. By comparing carefully many specimens of the same mineral, you learn to distinguish the accidental from the essential characters, and on this distinction you must base your inferences in regard to the nature of the specimens you may be called upon to determine. A single remark occurs to me which may aid you in cultivating this scientific logic.

Do not attempt to reason on insufficient data. Multiply your observations or experiments, and, when your premises are ample, the conclusion will generally take care of itself. Are you in doubt in regard to a mineral specimen? Repeat your observations again and again, multiply them with the aid of the blow-pipe or goniometer, compare the specimen with known specimens which it resembles, until either your doubts are removed, or you are satisfied that you are unequal to the task; and remember that, in many cases, the last is the only honest conclusion. Are you in doubt in regard to the reactions of the substance you are analyzing, whether they are really those of a metal you suspect to be present? Do not rest in such a frame of mind, and, above all, do not try to remove the doubt by comparing your experience with that of your neighbor: but multiply your own experiments; procure some compound of the metal, and compare its reactions with those you have observed, until you reach either a positive or a negative result. Remember that the way to remove your doubts is to widen your own knowledge, and not to depend on the knowledge of others. When your knowledge of the facts is ample, your inferences will be satisfactory, and then an unexplained phenomenon is the guide to a new discovery. Do not be discouraged if you have to labor long in the dark before the day begins to dawn. It will at last dawn to you, as it has dawned to others before, and, when the morning breaks, you will be satisfied with the result of your labor.

Moreover, I feel confident that such experience will very greatly tend to increase your appreciation of the value of scientific studies in training the reasoning faculties of the mind. This, as every one must admit, is the best test of their utility in a scheme of education, and it is precisely here that I claim for them the very highest place. It has generally been admitted that mathematical studies are peculiarly well adapted to train the logical faculties, but still many persons have main-

tained that, since the mathematics deal wholly with absolute certainties, an exclusive devotion to this class of subjects unfits the mind for weighing the probable evidence by which men are chiefly guided in the affairs of life. But, without attempting to discuss this question, on which much might be said on both sides, it is certain that no such objection can be urged against the study of the physical sciences if conducted in the manner I have attempted to describe. These subjects present to the consideration of the student every degree of probable evidence, accustoming him to weigh all the evidence for or against a given conclusion, and to reject or to provisionally accept only on the balance of probabilities. Moreover, in practical science, the student is taught to follow out a chain of probable evidence with care and caution, to eliminate all accidental phenomena, and supply, by experiment or observation, the missing links, until he reaches the final conclusion—an intellectual process which, though based wholly on probable evidence, may have all the force and certainty of a mathematical demonstration. Indeed, that highly-valued scientific acumen and skill which enables the student to brush away the accidental circumstances by which the laws of Nature are always concealed until the truth stands out in bold relief, is but a higher phase of the same talent which marks professional skill in all the higher walks of life. The physician who looks through the external symptoms of his patient to the real disease which lurks beneath; the lawyer, who disentangles a mass of conflicting testimony, and follows out the truth successfully to the end; the statesman, who sees beneath the froth of political life the great fundamental principles which will inevitably rule the conduct of the State, and thus foresees and provides for the coming change; the general, who discovers amid the confusion of the battle-field the weak point of his enemy's front; the merchant, even, who can interpret the signs of the unsettled market—employ the same faculty, and frequently in not a much lower degree, that discovered the law of gravitation, and which, since the days of Newton, has worked so successfully to unveil the mysteries of the material creation.

Moreover, I hope, my friends, that you will come to value scientific studies, not simply because they cultivate the perceptive and reasoning faculties, but also because they fill the mind with lofty ideals, elevated conceptions, and noble thoughts. Indeed, I claim that there is no better school in which to train the æsthetical faculties of the mind, the tastes, and the imagination, than the study of natural science. The beauty of Nature is infinite, and the more we study her works the more her loveliness unfolds. The upheaved mountain, with its mantle of eternal snow; the majestic cataract, with its whirl and roar of waters; the sunset cloud, with its blending of gorgeous hues, lose nothing of their beauty for him who knows the mystery they conceal. On the contrary, they become, one and all, irradiated by the Infinite Presence which shines through them, and fill the mind with grander

conceptions and nobler ideas than your uneducated child of Nature could ever attain. Remember that I am not recommending an exclusive devotion to the natural sciences. I am only claiming for them their proper place in the scheme of education, and I do not, of course, deny the unquestionable value of both the ancient and the modern classics in cultivating a pure and elevated taste. But I do say that the poet-laureate of England has drawn a deeper inspiration from Nature interpreted by science than any of his predecessors of the classical school; and I do also affirm that the pre-Raphaelite school of painting, with all its grotesque mimicry of Nature, embodies a truer and purer ideal than that of any Roman fable or Grecian dream. And what shall we say of the imagination? Where can you find a wider field for its exercise than that opened by the discoveries of modern science? And as the mind wanders over the vast expanse, crossing boundless spaces, dwelling in illimitable time, witnessing the displays of immeasurable power, and studying the adaptations of Omniscient skill, it lives in a realm of beauty, of wonder, and of awe, such as no artist has ever attained to in word, in sound, in color, or in form. And if such a life does not lead man to feel his own dependence, to yearn toward the Infinite Father, and to rest on the bosom of Infinite Love, it is simply because it is not the noble in intellect, not the great in talent, not the profound in knowledge, not the rich in experience, not the lofty in aspiration, not the gifted in imagery, but solely the pure in heart, who see God.

Such, then, is a very imperfect presentation of what I believe to be the value of scientific studies as a means of education. In what I have stated I have implied that, for these studies to be of any real value, the end must be constantly kept in view, and every thing made subservient to the one great object. To study the natural sciences merely as a collection of interesting facts which it is well for every educated man to know, seldom serves a useful purpose. The young mind becomes wearied with the details, and soon forgets what it has never more than half acquired. The lessons become an exercise of the memory and of nothing more; and if, as is too frequently the case, an attempt is made to cram the half-formed mind in a single school-year with an epitome of half the natural sciences—natural philosophy, astronomy, and chemistry, physiology, zoölogy, botany, and mineralogy, following each other in rapid succession—these studies become a great evil, an actual nuisance, which I should be the first to vote to abate. The tone of mind is not only not improved, but seriously impaired, and the best product is a superficial, smattering smartness, which is the crying evil not only of our schools, but also of our country. In order that the sciences should be of value in our educational system, they must be taught more from things than from books, and *never* from books without the things. They must be taught, also, by real living teachers, who are themselves interested in what they teach, are inter-

ested also in their pupils, and understand how to direct them aright. Above all, the teachers must see to it that their pupils study with the understanding and not solely with the memory, not permitting a single lesson to be recited which is not thoroughly understood, taking the greatest care not to load the memory with any useless lumber, and eschewing *merely* memorized rules as they would deadly poison. The great difficulty against which the teachers of natural science have to contend in the colleges are the wretched tread-mill habits the students bring with them from the schools. Allow our students to memorize their lessons, and they will appear respectably well, but you might as easily remove a mountain as to make many of them think. They will solve an involved equation of algebra readily enough so long as they can do it by turning their mental crank, when they will break down on the simplest practical problem of arithmetic which requires of them only thought enough to decide whether they shall multiply or divide. Many a boy of good capabilities has been irretrievably ruined, as a scholar, by being compelled to learn the Latin grammar by rote at an age when he was incapable of understanding it; and I fear that schools may still be found where young minds are tortured by this stupefying exercise. Those of us who have faith in the educational value of scientific studies are most anxious that the students who resort to our colleges should be as well fitted in the physical sciences as in the classics, for otherwise the best results of scientific culture cannot be expected. As it is, our students come to the university, not only with no preparation in physical science, but with their perceptive and reasoning faculties so undeveloped that the acquisition of the elementary principles of science is burdensome and distasteful: and good scholars, who are ambitious of distinction, can more readily win their laurels on the old familiar track than on an untried course of which they know nothing, and for which they must begin their training anew. We have improved our system of instruction in the college as fast as we could obtain the means, but we are persuaded that the best results cannot be reached without the coöperation of the schools. We feel, therefore, that it is incumbent upon us, in the first place, to do every thing in our power to prove to the teachers of this country how great is the educational value of the physical sciences, when properly taught; and, secondly, to aid them in acquiring the best methods of teaching these subjects. It is with such aims that our summer courses have been instituted, and your presence here in such numbers is the best evidence that they have met a real want of the community. We welcome you to the university and to such advantages as it can afford, and we shall do all in our power to render your brief residence here fruitful both in experience and in knowledge; hoping also that the university may become to you, as she has to so many others, a bright light shining calmly over the troubled sea of active life, ever suggesting lofty thoughts, encouraging

noble endeavors, and inciting all her children to work together toward those great ends, the advancement of knowledge and the education of mankind.

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# PHYSICAL FEATURES OF THE COLORADO VALLEY.[1]

By Major J. W. POWELL.

## II.—*Cliffs and Cañons.*

SOUTH of the Uinta Mountains, and beyond the hog-backs on either side of the river, is a district known to the Indians as *Wa-ka-ri'-chits*, or the Yellow Hills. This country is elaborately embossed with low, rounded, naked hills. The rocks from which they are carved are yellow clays and shales. Some few of the shales are slate-colored, others pink; none so glaring and brilliant as the Bad-Lands of Black's Fork, but the tints are soft and delicate. The whole country is carved by a net-work of water-ways, which descend rapidly toward Green River, and the intervening hills are entirely destitute of vegetation. Looking at it from an eminence, and in the light of the mid-day sun, it appears like a billowy sea of molten gold.

To the south of these Yellow Hills, and separated from them by a gently-curved but well-defined ridge of upturned sandstone, there is a broad stretch of red and buff-colored Bad-Lands. Some of the beds are highly bituminous, and a fresh fracture reveals a black surface, but usually they weather gray. Where these bituminous rocks are found, hills and *mesas* are seen, covered, more or less, with vegetation, and the Bad-Land forms disappear. Still farther to the south, across White River, we find a continuation of these beds, but here more shaly, and interstratified with harder beds, and the alcove structure appears, somewhat like that in the Alcove Land near Green River Station. These White River alcove lands were, by General Hughes, named "Goblin City."

The Terrace Cañons and Cliffs.—A few miles south of the mouth of the Uinta, Green River enters the Cañon of Desolation. The walls of this gorge steadily increase in altitude to its foot, where it terminates abruptly at the Brown Cliffs; then the river immediately enters Gray Cañon, with low walls, steadily increasing in altitude until the foot is reached, where it terminates abruptly at the Book Cliffs. In like manner the walls of Labyrinth Cañon are low above, and increase in altitude as we descend the river, until the cañon terminates, as those above, in a line of cliffs. To these last we have given the name Orange Cliffs. We sometimes call these the Terrace Cañons. They are cut through three great inclined plateaus.

[1] From "Report on United States Geological and Geographical Survey of the Territories, Second Division." Major J. W. Powell in charge.

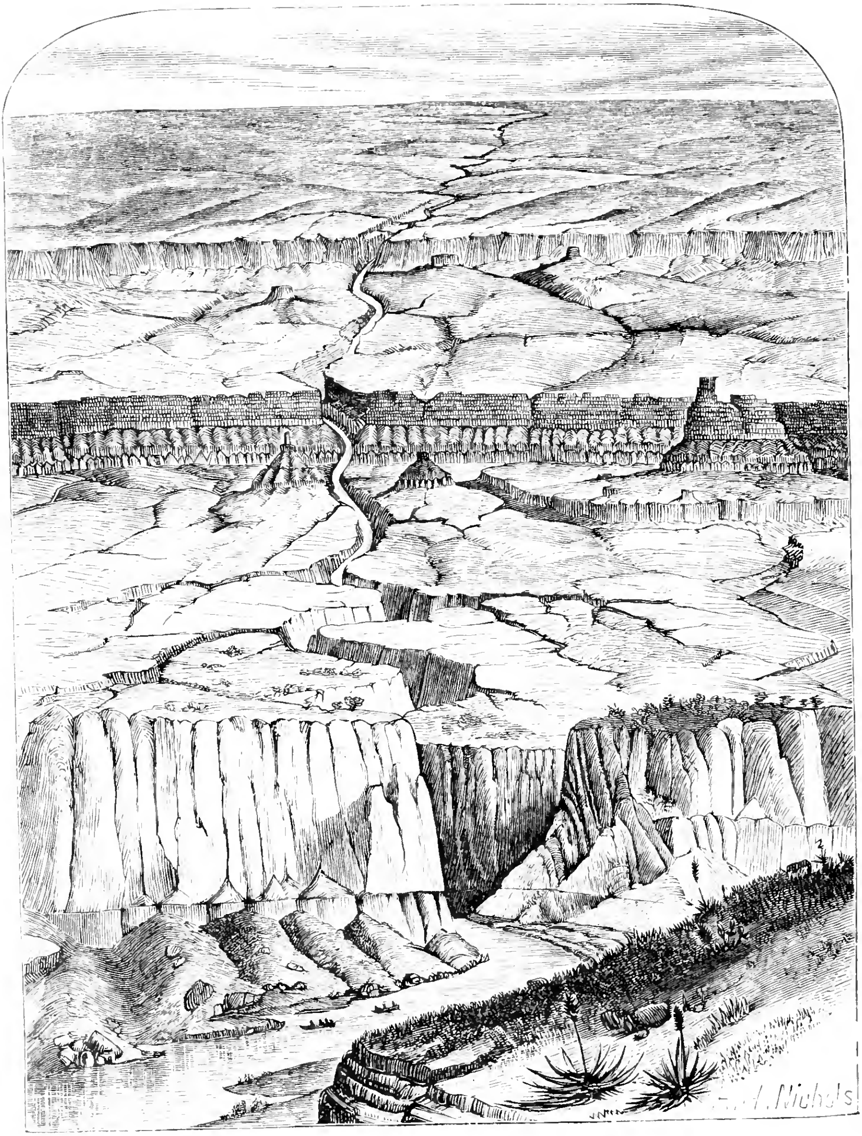



FIG. 1.—BIRD'S-EYE VIEW OF THE TERRACE CAÑON.

Conceive of three geographic terraces, many hundred feet high, and many miles in width, forming a great stairway, from the *Toom'-pin Wu-near' Tu-weap'*, below, to the valley of the Uinta, above. The lower step of this stairway, the Orange Cliffs, is more than 1,200 feet high, and the step itself is two or three score miles in width. The second step, the Book Cliffs, is 2,000 feet high, or more, and a score of miles in width. The third, or upper step, is more than 2,000 feet high. Passing along this step, for two or three score miles, we reach the valley of the Uinta; but this valley is not 5,000 or 6,000 feet higher than the *Toom'-pin Wu-near' Tu-weap'*, for the stairway is tipped backward.

Climb the Orange Cliffs, 1,200 feet high, and go north to the foot of the Book Cliffs, and you have gradually descended, so that at the foot of the Book Cliffs you are not more than 100 feet above the foot of the Orange Cliffs. In like manner the foot of the Brown Cliffs is but 200 feet higher than the foot of the Book Cliffs, and the valley of the Uinta is not quite 300 feet higher than the foot of the Brown Cliffs.

To go by land from the valley of White River to the *Toom'-pin Wu-near' Tu-weap'*, you must gradually, almost imperceptibly, climb as you pass to the south, for a distance of forty or fifty miles, until you attain an altitude of 2,500 or 3,000 feet above the starting-point. Then you descend from the first terrace, by an abrupt step, to a lower. Still continuing to the south, you gradually climb again, until you attain an altitude of more than 1,000 feet, when you arrive at the brink of another cliff, and descend abruptly to the top of the lowest terrace. Still extending your travels in the same direction, you climb gradually for a third time, until you reach the brink of the third line of cliffs, or the edge of the escarpment of the lower terrace, and here you descend by another sudden step to the plane of the river, at the foot of Labyrinth Cañon. In coming down by the river, of course you do not ascend, but you pass these terraces along the plane of the river, the upper terrace through the Cañon of Desolation, the middle terrace through Gray Cañon, and the third through Labyrinth Cañon.

The bird's-eye view (Fig. 1) is intended to show these topographic features. The escarpment below, and in the foreground, represents the Orange Cliffs, at the foot of Labyrinth Cañon; the second escarpment, the Book Cliffs, at the foot of Gray Cañon; the third, away in the distance, the Brown Cliffs, at the foot of the Cañon of Desolation. It will be seen that the three tables incline to the north, and are abruptly terminated by cliffs on the south. For want of space the whole view is shortened.

In the three cañons there are three distinct series of beds, belonging to three distinct geological periods. In the Cañon of Desolation we have Tertiary sandstones; in Gray Cañon, Cretaceous sandstones, shales, and impure limestones; between the head of Labyrinth Cañon

and the foot of Gray Cañon, rocks of Cretaceous and Jurassic Age are found, but they are soft, and have not withstood the action of the water so as to form a cañon.

These formations differ not only in geological age, but also in structure and color. It will be interesting to notice how these structural differences affect the general contour of the country, and modify its scenic aspects.

In the description of the three cañons in the history of their exploration, the attentive reader has already noticed the great variety of geological and topographic features observed as we passed along.

Let us now take a view of the three lines of cliffs. The Brown Cliffs are apparently built of huge blocks of rock, exhibiting plainly the lines of stratification. The beds are usually massive and hard, and break with an angular fracture. The whole is very irregular, and set with crags, towers, and pinnacles. The upper beds of the Book Cliffs are somewhat like those last described, and they form a cap to extensive laminated beds of blue shales, in which we see exhibited the curious effects of rain-sculpture. The whole face of the rock is set with buttresses, and these are carved with a fretwork of raised and rounded lines, that extend up and down the face of the rock, and unite below in large ridges. The little valleys between these ridgelets are the channels of rills that roll down the rocks during the storms, and from one stand-point you may look upon millions of these little water-ways.

Labyrinth Cañon is cut through an homogeneous sandstone. The features of the cañon itself have been described, but the cliffs with which it terminates present characteristics peculiar to themselves. Below, we have rounded buttresses, and mounds and hills of sand, and piles of great, angular blocks; above, the walls are of columnar structure, and sometimes great columns, seen from a distance, appear as if they were elaborately fluted. The brink of this escarpment is a well-defined edge. But if these formations extended over the underlying beds at one time, and if they have been carried away by rains and rivers, why has not the country between been left comparatively level, or embossed with hills separated by valleys? It is easy to see that a river may cut a channel, and leave its banks steep walls of rocks; but that rains, which are evenly distributed over a district, should dig it out in great terraces, is not so easy to perceive.

The climate is exceedingly arid, and the scant vegetation furnishes no protecting covering against the beating storms. But though little rain falls, that which does is employed in erosion to an extent difficult to appreciate by one who has only studied the action of water in degrading the land in a region where grasses, shrubs, and trees, bear the brunt of the storm. A little shower falls, and the water gathers rapidly into streams, and plunges headlong down the steep slopes, bearing with it loads of sand, and for a few minutes, or a few hours, the

district is traversed by brooks and creeks and rivers of mud. A clear stream is never seen without going up to a moister region on some high mountain, and no permanent stream is found, unless it has its source in such a mountain. In a country well supplied with rains, so that there is an abundance of vegetation, the water slowly penetrates the loose soil, and gradually disintegrates the underlying solid rock, quite as fast as, or even faster than, it is carried away by the wash of the rains, and the indurated rock has no greater endurance than the more friable shales and sandstones; but, in a dry climate, the softer rocks are soon carried away, while the harder rocks are washed naked, and the rains make but slow progress in tearing them to pieces.

When a great fold emerges from the sea, or rises above its base level of erosion, the axis appears above the water (or base-level) first, and is immediately attacked by the rains, and its sands are borne off to form new deposits. It has before been explained that the emergence of the fold is but little faster than the degradation of its surface, but, as it comes up, the wearing away is extended still farther out on the flanks, and the same beds are attacked in the new land which have already been carried away nearer the centre of the fold. In this way the action of erosion is continued on the same bed from the upturned axis toward the down-turned axis, and it may and does often happen that any particular bed may be entirely carried away, with many underlying rocks, nearer the former line, before it is attacked near the latter. Now, as the beds are of heterogeneous structures, some hard and others soft, the harder beds withstand the action of the storms, while the softer beds are rapidly carried away.

The manner in which these beds are degraded is very different. The softer are washed from the top, but the harder are little affected by the direct action of the waters—they are torn down by another process. As the softer beds disappear, the harder are undermined, and are constantly breaking down; are crushed, more or less, by the fall, and scattered over, and mingled with the softer beds, and are carried away with them. But the progress of this undermining and digging down of the cliff is parallel with the upturned axis of the fold, so that the cliffs face such an axis.

When the fold is abrupt, so that the rocks on either side are made to incline at a great angle, ridges are formed, and this topographic structure of a country may be found even in a land of rains, though the ridges will usually be low, rounded, and more or less irregular, while in a dry climate they will be steep and regular, and will usually culminate above in a sharp edge; but where the rocks are slightly inclined, terraces will be formed, with well-defined escarpments.

It is interesting to note the manner in which the textures of these hard capping rocks affect the contours of the cliffs. When the hard rocks are separated into well-defined layers, or beds, the cliffs will be more or less terraced, as the strata vary in hardness. This is well

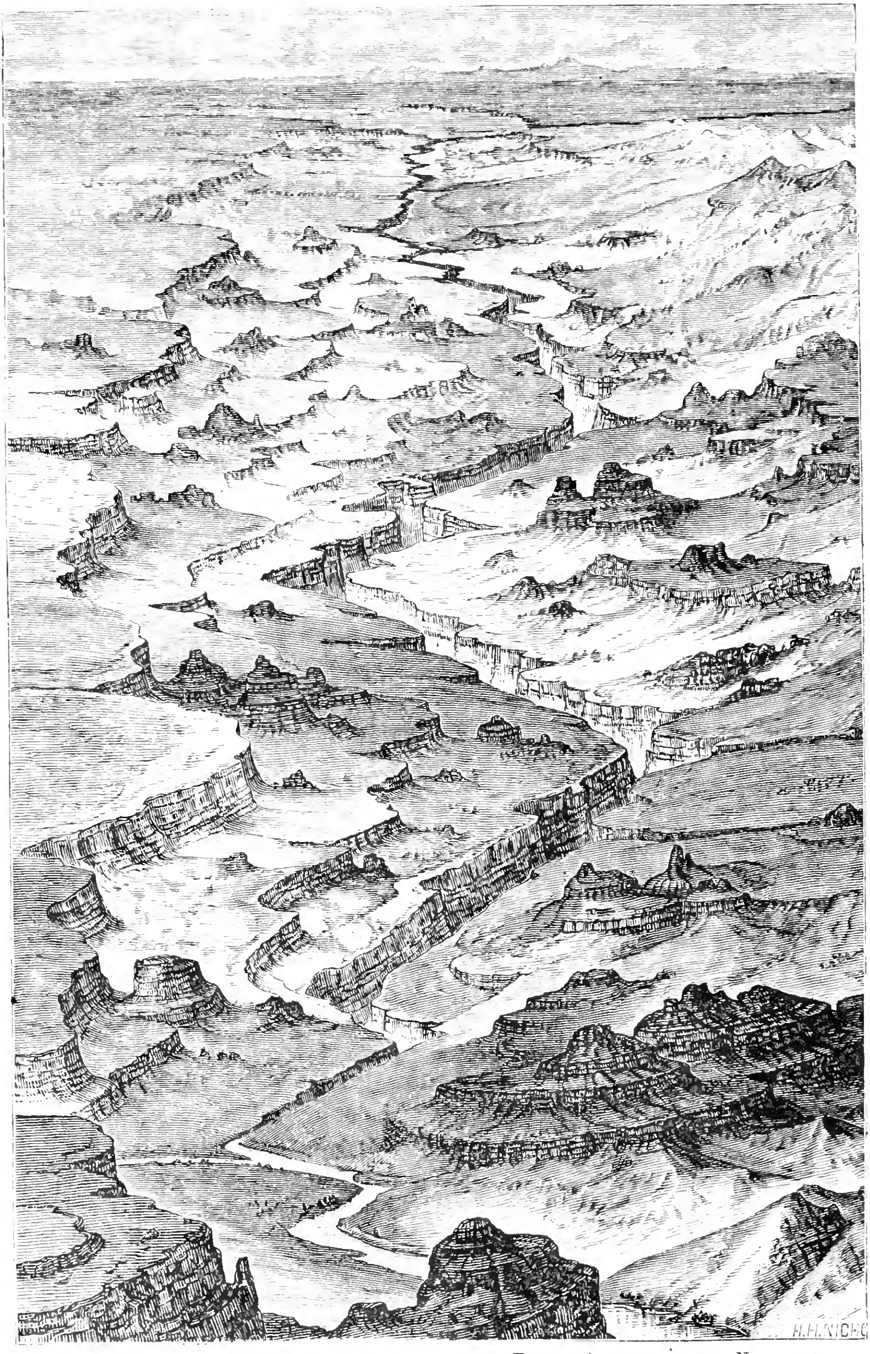


FIG. 2.—BIRD'S-EYE VIEW OF THE TOOM'-PIN WU-NEAR' TU-WEAP' LOOKING TO THE NORTHEAST, showing the Sierra la Sal on the Right, the Cañons through the Centre, and Lines of Cliffs on the Left.

seen in the Brown Cliffs and the upper portion of the Book Cliffs. In the last-mentioned escarpment the harder beds are underlaid by soft, bluish shales, which appear below in the beautifully-carved buttresses.

In the Orange Cliffs there are a thousand feet of homogeneous light-red sandstone, and this is underlaid by beds of darker red, chocolate, and lilac-colored rocks, very distinctly stratified. The dark-red rocks are very hard, the chocolate and lilac are very soft, so below we have terraced and buttressed walls and huge blocks scattered about, which have fallen from the upper part of the escarpment. The homogeneous sandstone above is slowly undermined—so slowly that, as the unsupported rocks yield to the force of gravity, fissures are formed parallel to the face of the cliff. Transverse vertical fissures are also formed, and thus the wall has a columnar appearance, like an escarpment of basalt, but on a giant scale; and it is these columns that tumble over at last, and break athwart into the huge blocks which are strewed over the lower terraces.

The drainage of an inclined terrace is usually from the brink of the cliff toward the foot of the terrace above, i. e., in the direction of the dip of the strata. As the channels of these intermittent streams approach the upper escarpment, they turn and run along its foot until they meet with larger and more permanent streams, which run against the dip of the rock in a direction opposite the course of the smaller channels, and these latter usually cut either quite through the folds, or at least through the harder series of rocks which form the cliffs.

In some places the waters run down the face of the escarpment, and cut narrow cañons, or gorges, back for a greater or less distance into the cliffs, until what would, otherwise, be nearly a straight wall, is cut into a very irregular line, with salients and deep reëntering angles.

These cañons which cut into the walls also have their lateral cañons and gorges, and sometimes it occurs that a lateral cañon from each of two adjacent main cañons will coalesce at their heads, and gradually cut off the salient cliff from the ever-retreating line. In this way buttes are formed. The sides of these buttresses have the same structural characteristics as the cliffs from which they have been cut. So the buttes on the plains below the Orange Cliffs are terraced and buttressed below, and fluted and columned above. Often the upper parts of these buttes are but groups of giant columns.

The three lines of cliffs, which I have thus described, have been traced to the east but a few miles back from the river. The way in which they terminate is not known; but, from a general knowledge obtained from a hasty trip made through that country, it is believed that they are cut off by a system of monoclinal folds. To the west they are known to gradually run out in plateaus and mountains, which have another orographic origin.

Climb the cliff at the end of Labyrinth Cañon, and look over the plain below, and you see vast numbers of buttes scattered about over scores of miles, and every butte so regular and beautiful that you can hardly cast aside the belief that they are works of Titanic art. It seems as if a thousand battles had been fought on the plains below, and on every field the giant heroes had built a monument, compared with which the pillar on Bunker Hill is but a mile-stone. But no human hand has placed a block in all those wonderful structures. The rain-drops of unreckoned ages have cut them all from the solid rock.

Between the foot of Gray Cañon and the head of Labyrinth Cañon we descend through many hundred feet of soft shales, sandstones, marls, and gypsiferous rocks of a texture so friable that no cañon appears along the course of the Green, but, along the southern border of the terrace above the Orange Cliffs, buttes of gypsum are seen. Sometimes the faces of these buttes are as white as the heart of the alabaster from which they are carved, while in other places they are stained and mottled red and brown.

As we come near to the Book Cliffs the buttes are seen to be composed of the same beds as those seen in the escarpment, and we see the same light-blue buttresses and terraced summits.

On the terrace above the Book Cliffs, the buttes are less numerous, but the few seen have the angular, irregular appearance of the Brown Cliffs.

The summit of the high plateau through which the Cañon of Desolation is cut, is fretted into pine-clad hills, with nestling valleys and meadow-bordered lakes, for now we are in that upper region where the clouds yield their moisture to the soil. In these meadows herds of deer carry aloft with pride their branching antlers, and sweep the country with their sharp outlook, or test the air with their delicate nostrils for the faintest evidence of an approaching Indian hunter. Huge elk, with heads bowed by the weight of ragged horns, feed among the pines, or trot with headlong speed through the undergrowth, frightened at the report of the red-man's rifle. Eagles sail down from distant mountains, and make their homes upon the trees; grouse feed on the pine-nuts, and birds and beasts have a home from which they rarely wander to the desert lands below. Among the buttes on the lower terraces rattlesnakes crawl, lizards glide over the rocks, tarantulas stagger about, and red ants build their play-house mountains. Sometimes rabbits are seen, and wolves prowl in their quest; but the desert has no bird of sweet song, and no beast of noble mien.

The Toom'-pin Wu-near' Tu-weap'.—We now proceed to the discussion of Stillwater Cañon, Cataract Cañon, and Narrow Cañon, and the region of country adjacent thereto.

At the head of Stillwater Cañon the river turns to a more easterly

course, and runs into a fold, which has a northeast and southwest axis, but its central line is never reached. Before coming to it the river turns again to the west, and runs entirely out of the fold, at the mouth of the Dirty Devil River. It will thus be seen that the dip of the formations under discussion is to the northwest. Going down to the middle of Cataract Cañon, we constantly see rocks of lower geological position appearing at the water's edge; and, still continuing from that point to the foot of Narrow Cañon, the same beds are observed in reverse order; that is, we see at the water's edge rocks of later geological age.

Where the upturned axis of this fold is situated is not known; but, looking away to the southeast, mountains are seen—the Sierra La Sal and Sierra Abajo. Looking over the general surface of the country, it appears that the course of the river is from lower into higher lands, and then back again. Observing the present topographic features of the country, it seems strange that it did not find its way directly across from the foot of Labyrinth to the foot of Narrow Cañon, following the low lands. Why should it leave this low region, and run away out into the slope of a system of mountains, and then return? We must remember that the river is older than the mountains and the cliffs. We must not think of a great district of country, over which mountains were piled, or built, or heaved up, and that when rain fell it gathered into streams along the natural depressions of such a country, and thus attempt to account for the course of the river; but we must understand that the river cut its way through a region that was slowly rising above the level of the sea, and the rain washed out the valleys, and left rocks and cliffs standing, and the river never turned aside from its original course to seek an easier way, for the progress of uplifting was not greater than that of corrasion. Again we see how slowly the dry land has emerged from the sea; no great convulsion of Nature, but steady progress.

The Orange Cliffs, which terminate Labyrinth Cañon, extend to the west a few miles, and then change their course to the southwest, running parallel with the axis of the fold we are now discussing, and they cross the Dirty Devil a few miles above its mouth. Thus they are seen, like the other lines of cliffs, to face the axis of a fold. Fig. 2 is a bird's-eye view of this country, showing the course of the river through Stillwater, Cataract, and Narrow Cañons. It represents the cutting of the stream into the slope of a mountain-range, and out of it again, without crossing the range. On the left it shows two lines of cliffs. Here we have a district inclosed within Titanic walls. On the southeast are great mountains, and from the foot of their slope, on the north side, near Grand River, we find a line of cliffs crossing this stream, and extending to the Green, in a westerly direction; then to the southwest, to the Dirty Devil River, and then broken and confused by buttes and cañon-walls, which extend toward the east, until it

strikes the southern foot of the mountains. Within this walled area a profound gorge—Cataract Cañon—is seen, with Stillwater Cañon above, and Narrow Cañon below. The lower cañon of the Grand is also seen, and a number of lateral cañons.

Along the general slope of the district between the cañons are vast numbers of buttes. Their origin is the same as that of the buttes previously described. Often they are but monuments, or standing columns of rocks. From them is derived the Indian name *Toom'-pin Wu-near' Tu-weap'*—"the Land of Standing Rocks."

Adjacent to the larger cañons, especially near the junction of the Grand and Green, walled coves are found. Each main gulch branches into a number of smaller gulches above, and each of these smaller gulches heads in an amphitheatre. The escarpments of these amphitheatres are broken and terraced, and in many places two such amphitheatres are so close together that they are separated only by a narrow gorge of vertical homogeneous sandstone.

This latter, though homogeneous in general structure, is banded with red and gray, so that the walls of the amphitheatres seem painted. In many places these walls are broken, and the coves are separated by lines of monuments. Where these coves or amphitheatres are farther apart, the spaces above are naked, presenting a smooth but billowy pavement of sandstone, in the depressions of which are many water-pockets, some of them deep, preserving a perennial supply; but the greater number so shallow that the water is evaporated within a few days after the infrequent showers.

In many places, especially in the sharp angles between gulches, the rocks are often fissured, and huge chasms obstruct the course of the adventurous climber.

These cañons, and coves, and standing rocks, and buttes, and cliffs, and distant mountains, present an *ensemble* of strange, grand features. Weird and wonderful is the *Toom'-pin Wu-near' Tu-weap'*.

Marble Cañon.—The escarpment, which we call the "Vermilion Cliffs," at the foot of Glen Cañon, exposes the same beds as are seen in the face of the Orange Cliffs, at the foot of Labyrinth Cañon. It will be remembered that the beds exposed in the Terrace Cañons dip to the north. Between the Orange Cliffs and the Vermilion Cliffs, the strata are variously dipped by monoclinal folds, having their axes in a northerly and southerly direction, and the red beds are at about the same altitude above the sea at the two points. The Vermilion Cliffs which face the south form a deep, reëntering angle at the mouth of the Paria. On the east side of the Colorado, the line stretches to the southeast for many miles; on the west side, it extends, in a southwesterly direction, about fifteen miles, then turns west, and, at last, to the northwest. The general northerly dip is again observed from the mouth of the Paria to the mouth of the Colorado Chiquito.

The general surface of the country between the two points is the

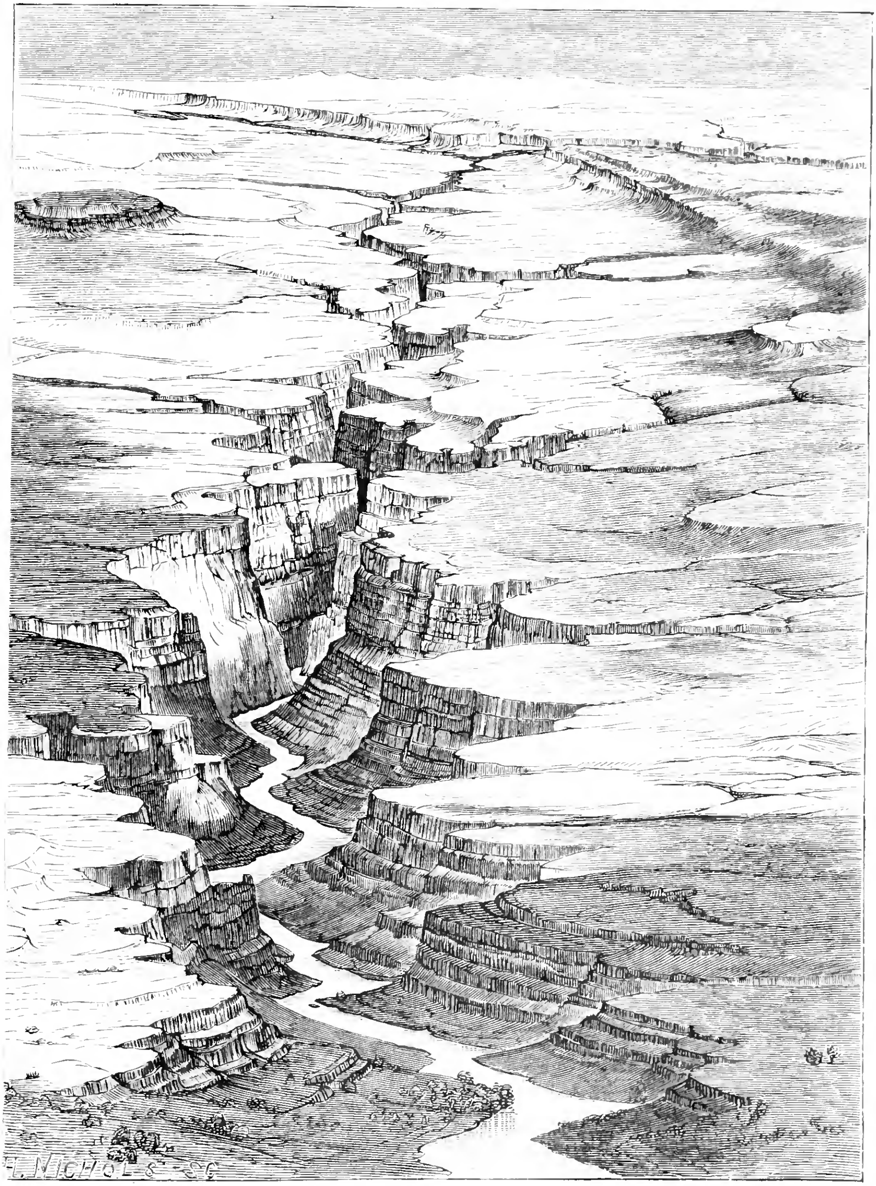



Fig. 3.—Bird's-eye View of Marble Cañon from the Vermilion Cliffs, near the Mouth of the Paria. In the distance the Colorado River is seen to turn to the west, where its gorge divides the Twin Plateaus. On the right are seen the Eastern Karbab Displacements appearing as folds, and farther in the distance as faults.

summit of the Carboniferous formation. At the mouth of the Paria this is at the water's edge; at the mouth of the Colorado Chiquito it is 3,800 feet above the river. The fall of the river, in the same distance, is about 600 feet, so that the whole dip of the rock between the two points is about 3,200 feet. The distance, by river, is sixty-five miles; in a direct line, twenty miles less. So we have a dip of the formation of 3,200 feet in forty-five miles, or about seventy feet to a mile.

The slope of the country to the north is the same as the dip of the beds, for the country rises to the south as the beds rise to the south.

Stand on the Vermilion Cliffs, at the head of Marble Cañon, and look off down the river over a stretch of country that steadily rises in the distance until it reaches an altitude far above even the elevated point of observation, and then see meandering through it to the south the gorge in which the river runs, everywhere breaking down with a sharp brink, and in the perspective the summits of the walls appearing to approach until they are merged in a black line, and you can hardly resist the thought that the river burrows into, and is lost under, the great inclined plateau.

## A POPULAR VERDICT.

THE life of Robert Knox, the celebrated Edinburgh anatomist, written by his friend and pupil Dr. Lansdale, is a work of much interest on account of the contributions to science made by that remarkable man; but there were some tragic features in his career which, taken in connection with the stupid and brutal "public opinion" of which he was made the victim, have an instructiveness of a quite different kind, yet of such importance that it is desirable they should not be forgotten. We can give here but a very imperfect sketch of the case, and would refer curious readers to Dr. Lansdale's book, from which we condense the following statement, making free use of the language of the author.

Robert Knox, who is numbered among the descendants of the sturdy Scotch reformer, was born in 1791. He was educated at the High-School of Edinburgh, which boasted of many great names, such as Brougham, Horner, and Cockburn, in the long roll of its illustrious alumni. But few of its students showed more brilliant parts than young Knox, who rose, apparently without effort, to the head of every class, and came out gold-medalist in 1810. He joined the medical classes of Edinburgh the same year, but pursued a broad course of literary, historical, and scientific studies, together with those bearing more immediately upon the medical profession. He early took a prom-

inent place as a student of large acquirements, and twice occupied the presidential chair of the Royal Physical Society before his graduation. On his first examination for the M. D., Knox was "plucked" in anatomy. Thrown upon his metal by this untoward circumstance, he took hold of the subject so thoroughly that he became profoundly interested, was captivated by it, and chose it as the work of his life. He became an able physician and surgeon, and was sent to Brussels by the government, to render aid to the wounded of Waterloo. He joined the army in 1817, and spent three years in Africa engaged in hospital-practice. But, with a capacity for wide observation, he occupied himself with physical geography and meteorology, and more especially with natural history and ethnology. He collected and dissected specimens from every division of the animal kingdom; but man being his chief study, he took every opportunity of dissecting the natives whose bodies fell in his way through the contingencies of war; and thus added much to what was known of their peculiar anatomical characters and physiological traits. He was a skillful horseman, an intrepid hunter, and an excellent shot. Long after his sojourn among the colonists of the Cape of Good Hope, he was remembered with admiration, and spoken of as a man of transcendent abilities and accomplishments. He returned to England in 1820, and, after receiving the thanks of the army medical department for his "industry, zeal, and talents," he got leave of absence for a year, to study in the medical schools of the Continent. In Paris he made the acquaintance of Cuvier, De Blainville, Larrey, and St.-Hilaire; and to the views of the latter on the higher anatomy he became a convert. A man of great industry and originality, he produced memoirs on a wide range of subjects, which were published in the Transactions of various societies.

In 1824, Dr. Knox submitted to the Edinburgh College of Surgeons a plan for the formation of a museum of comparative anatomy, which was accepted; the scientific arrangement and active management of the establishment devolving upon the proposer. He purchased Sir Charles Bell's collection for £3,000, and brought it from London to Edinburgh. He was conservator of the museum thus formed, and classified, catalogued, and extended the collection, so as to make it most valuable for anatomical, surgical, and pathological students. After seven years' work, he left it one of the most extensive and valuable collections in Europe.

Edinburgh was at that time a prominent centre of medical study. The fame of its professors drew crowds of students to the university. But the teaching of anatomy was mainly an outside affair; that is, it was conducted in private institutions, independent of the university. Several eminent anatomists had lectured to preparatory classes in these schools, and in 1825 the leading man in this field was Dr. John Barclay, a thorough anatomist and accomplished lecturer, who had a large class of students. Dr. Barclay was the author of many valu-

able anatomical works; and in illustration of his character it may be mentioned that one day Henry Brougham, afterward Lord Brougham, then on the staff of the *Edinburgh Review*, asked the doctor to give him half an hour's talk on anatomy, to enable him to write a critique on one of his (Barclay's) books. This is a fair sample of the capital on which the noble quack earned his scientific reputation. The anatomist refused the request and resented the impertinence. Dr. Barclay was, however, getting old, and he formed a partnership with Knox in the management of the school. He soon after died, and Dr. Knox became master of the establishment. He at once rose to unexampled popularity. In the first place, he was a man of profound, comprehensive, and thorough erudition. Anatomy was not with him a mere ordinary occupation, but an object of high philosophical research, and pursued with enthusiasm. He was early to recognize the two divisions—anatomical science and anatomical art—the former embracing the elucidation of the nature or structure and organization of animal bodies; the latter comprehending all those means and contrivances by which organisms can be dissected and demonstrated. He was one of the first of philosophic biologists. When he began to teach, human anatomy was treated very much as a superficial and technical pursuit, to be dispatched in a three months' course of dissections, by the majority of medical students. To some lecturers, a bone was a structure with certain physical features, and nothing more. Knox made it assume an historical position in the scale of organization; its size and form were obvious enough, but he sought in the osteogenesis, type, and homologues, to fix its place in the general superstructure of the animal series. In short, he gave not the mere description but the philosophy of the osseous form. "There was no circumlocution in his teachings; he aimed at a clear delineation of the work before him. He was more practical than minute, more suggestive than analytic in his systematic course; rather than linger on points of detail, he indicated the path to be pursued by the student. His mode of teaching was not suited to the 'grinding' or 'cramming' system; hence those who sought anatomy for examining boards went elsewhere. His prelections were well adapted to stimulate thought, as he meant them to do. Being a surgeon and pathologist, Knox could significantly apply anatomy to a practical calling; and as a physiologist of high aim, he looked to zoölogy as a *sine qua non* to the study of the higher philosophy of man himself."

Dr. Knox was an orator of the first class, a tight-made man, above the middle stature, of the nervo-sanguineous temperament, broad-chested, with an upright carriage, a firm and soldierly walk, and a free and lithesome action. He had a strikingly fine head, but a plain visage, an agreeably-toned voice, and a persuasive tongue that made captive every listener who could appreciate colloquial excellence. He had a weakness for elegance of dress, and attended carefully to all

the arts by which an audience can be fascinated; but he never lost his suave demeanor and high respect for his class as a body of gentlemen. His movements were graceful, and his gestures, now slow and now rapid, had a rare felicity and pertinence to the matter in hand. His style, his illustrations, and insinuating speech, lent a marvelous fascination to his subject, and he stood before his class the impersonation of lofty intellect and perfect self-possession. He was an ideal lecturer. The area of his class-room was to Knox a charmed circle. There he exercised a weird influence that traversed from side to side the thronged benches and subtly pervaded the mind of every member of his audience.

As a consequence of these traits, of the solidity and breadth of his knowledge, and of the consummate art of his delivery, Dr. Knox was to an extraordinary degree popular with his classes. At all times accessible and ready to offer kindly and encouraging counsel, he became the "guide, philosopher, and friend," of every worthy student. His pupils loved him and lauded him to the skies, and his anatomical classes were larger than any other ever assembled in Britain. Country physicians rode twenty miles to attend his introductory lectures. "The benches of Knox's class-room were occupied by a scholarly, earnest, and appreciative class; the majority were strictly medical students, but mingling with these were English barristers, Cambridge scholars and mathematicians, Scottish advocates and divines, scions of the nobility, artists, and men of letters. The zoölogists and naturalists flocked to Knox for their comparative anatomy. General students looked upon him as the great master of his art, and fully indorsed the encomiums bestowed upon him by Audubon and others of still greater eminence, both Continental and Transatlantic. Military and naval surgeons, in active service or on half-pay, often mingled with the crowd. Cultivated men of all kinds were attracted by his fame, and looked upon his instructions as the greatest intellectual treat afforded them in the modern Athens; while among his students it was remarked that the higher their intellectual grade, the more profound was their admiration of his genius and their personal attachment to him."

As an indication of how Dr. Knox was regarded by his class, his biographer states: "There was a struggle to obtain good places in Knox's lecture-room each day at eleven o'clock. The first year's students attending chemistry, and the second year's men attending surgery, between the hours of ten and eleven, were the chief claimants for Knox's front seats. The university, from whose class-rooms the majority of Knox's men came to hear his morning lecture, was about three minutes' walk from Old Surgeons' Hall—Knox's place. The competitors in their flight down two staircases, from Hope's Chemistry Rooms, their racing across the quadrangle of the university, their sweeping rush over every obstacle to gain Infirmary Street,

offered an exciting spectacle. The race was neck and neck, and woe betide whoever fell in the way! Old and young passers-by were thrown down in the *mêlée* caused by scores of agile-limbed fellows contending for the Knox goal. The rare and intense enthusiasm that Knox created in his class belongs to the past; no such high fervor is manifested by the student of these latter days. The reason is obvious: he who called it forth is gone, and his counterpart is nowhere to be found; indeed, it is more than doubtful if another Knox will ever appear before a British audience. Old pupils of Knox, both privately and publicly, still speak with sparkling eyes of the grand excitement and rush for favored seats in his lecture-room."

Robert Knox was, moreover, a hater of all humbug, and an unsparing critic of shams of every sort. He ridiculed the superficial method of teaching anatomy practised by rival lecturers, and in his sudden bursts of oratory, his sharp, pithy sentences, which came like sparks from a furnace, often created havoc among doubtful medical reputations, and his telling sarcasms would often circulate through Scotland. It was therefore impossible that he should not make many enemies. His very eminence and popularity also could not fail to be a source of hostility on the part of the envious and jealous. Often his class seemed spellbound under the influence of a speech; and as he wound up his lecture with increasing emphasis, and a sweeping torrent of rhetoric, and bowed his exit, the crowded audience would often rise *en masse*, waving their hats and handkerchiefs, and cry: "Bravo! bravo! Knox forever, and one cheer more!" All this was delightful; but, as this world is constituted, men often have to pay dearly for such things; and so did Dr. Knox.

Anatomy is the foundation of surgery, and the basis of all rational medical science. To know the structure of the human organization is indispensable both to the progress and the intelligent practice of the healing art. A knowledge of anatomy is therefore the first condition of the most important and beneficent of all occupations—that of alleviating human suffering and saving human life. But the knowledge of the human body that is necessary to remedy its diseases cannot be obtained except by studying it through and through; and this can only be done when the corporeal fabric becomes useless for other purposes. Dead bodies, worthless for any thing else, are invaluable for dissection, and if dissected they must of course be obtained for the purpose. Yet, with an absurd inconsistency, governments, while exacting of medical students a knowledge that can only be procured by the dissection of corpses, have at the same time outlawed the procurement of subjects. Such has been the policy of states for centuries, and in pursuing it the civil power has but given expression to one of the profoundest prejudices and most wide-spread superstitions of human nature. Antipathy to dissection after death is a deeply-rooted

feeling that has been manifested by all nations, creeds, and peoples—Egyptian, Greek, Roman, Mohammedan, Christian, and Jew. The primitive Christians, as evinced by their epitaphs, cursed the disturbers of their remains in the Roman Catacombs. When science was regarded as little else than magic, and diseases were ascribed to the influence of the devil, physicians were looked upon as sorcerers, and it was but natural that those who considered that their bodies were destined to resurrection should entertain a hatred and horror of those who would cut it up in the dissecting-room for base purposes of utility. And when governments in modern times began to concede a restricted privilege of dissection, the mode of doing it only served to heighten the horror with which the operation was popularly regarded. For three centuries the law increased the infamous reputation of dissection by making it follow the work of the gallows. These feelings were peculiarly intense in theological Scotland, so that the modern medical schools had the greatest difficulty in getting even a few subjects for anatomical study. The necessity of having them, however, created a special craft of body-snatchers and robbers of graveyards. Nothing was more calculated to infuriate the populace than to discover that a grave had been violated. The church-yard was a sacred precinct, "God's acre," and the removal of a body from it was treated as an impious interference with the plans of Providence respecting the great resurrection—the body-stealers being accordingly named "resurrectionists." The men who took to this vocation were of the lowest and most brutal sort. None but base and desperate rascals, indifferent to public detestation, would pursue a business so reprobated by all classes, and so the very quality of the men added repulsiveness to the occupation. Yet physicians were constantly compelled to coöperate with these wretches; that is, to buy their plunder and keep their secrets, as the very first condition of sound medical education. But government, with its legal enactments, joined the superstitious masses in arresting the work of anatomy and making it unlawful and impracticable. The physicians petitioned the authorities for relief, and were answered with more stringent enactments, prosecutions, and spies and detectives watching the doors of medical schools. These schools in Edinburgh were sacked by mobs or starved into suspension by the impossibility of obtaining subjects. "The law virtually proclaimed that the surgeon should possess aptitude and skill as well as a formal license to practise; nay, it went further, and subjected him who failed to display proper skill to pecuniary forfeiture in the civil courts at the instigation of any dissatisfied patient; yet the only mode of acquiring that skill—namely, from dissections of the dead clandestinely obtained—was in the criminal court held to be a misdemeanor, punishable by fine and imprisonment."

Such was the state of things in Edinburgh when Dr. Knox entered upon the public teaching of anatomy. With the unprecedent-

ed enlargement of his classes, which sometimes rose to more than five hundred students; and with his thorough-going views of the importance of actual dissection to the well-prepared physician, the demands of his establishment for subjects were necessarily large. These he had, of course, to meet in various ways. The home supply of bodies being insufficient, he made arrangements with distant places in England and Ireland to have subjects sent to Edinburgh. He was often compelled to pay so high for cadavers that it consumed the profits of his teaching, and in one session he lost nearly $4,000 from this cause alone. An enthusiast himself, and with an enthusiastic class, he could not endure to see the bare dissecting-tables, or to hear the importunate solicitations of his students seeking for professional opportunities that were denied them away from a medical school. Not infrequently the professors of medical colleges have joined the resurrectionists in their midnight adventures, or have pursued them alone; and many thrilling stories are recorded of their nocturnal exploits in getting possession of subjects which offered special interest to the anatomists. But Dr. Knox never indulged in these practices. He despised the resurrectionists whom he was compelled to use, and did his best to get a change of legislation by which anatomy might be prosecuted in a legal and legitimate way. Failing to secure this, he had to resort to the usual expedients for facilitating anatomical study—expedients as old as medical science.

On the 29th of November, 1827, an old man by the name of Donald died in West Port, one of the purlieus of Edinburgh. He lodged with an Irishman named William Hare, and died owing him four pounds. His creditor saw but one way of reimbursing himself, and that was by disposing of the old man's body to the doctors. Hare found a ready accomplice in William Burke, another Irishman, and also one of his lodgers. The body was removed from the coffin, and a bag of tanner's bark substituted for it. The lid was screwed down and the little funeral went off as usual. The same evening, Hare and Burke stealthily repaired to the university, and, meeting a student in the yard, asked for the rooms of Dr. Monroe, the Professor of Anatomy. The student happened to be a pupil of Knox's, and, upon discovering their errand, he advised them to try Knox's place in Surgeons' Square. There they sold the body for £7 10*s.*, a large sum for them, and very easily obtained. They had not courage to go into the regular business of body-stealing; and so Hare, the vilest of the two, suggested a fresh stroke of business, which was to inveigle the old and infirm into his quarters and "do for them." Hare started in search of a victim; and, prowling through the slums, met an old woman half drunk, and asked her to his house. He gave her whiskey until she became comatose, and then with Burke's assistance strangled her. The body brought £10.

The appetite of the vampires was now sharply whetted, and they entered systematically upon the work of murder. Vagrants, street-walkers, and imbeciles, were allured on various pretexts to the house of Hare, made dead drunk, and suffocated. Emboldened by their successes, they began to pursue their thuggish practices even in daylight. A woman named Docherty was stifled, and her body left half-exposed under some straw was seen by two lodgers, who notified the police. Thirteen victims had been secured in eleven months, and all taken to the same place and sold. The prisoners were tried December 24, 1828, when Hare, the blackest of the villains, was let off by turning "state's evidence," and Burke was convicted, hanged, and dissected.

The effect produced upon the public by this horrible disclosure is indescribable. A new and unheard-of crime, that of "Burking," was added to the list of atrocities of which human fiends are capable. Astonishment and terror spread through the community. Households gathered their members within-doors before dusk; workmen walked home from their night's toil in groups, as if in fear of being waylaid. The facts were appalling enough; but a thousand exaggerations and inventions filled the air, and intensified the universal excitement.

It could hardly be expected that public feeling, under such circumstances, would be restrained within the bounds of reason, but it went to the most outrageous excesses. Those who were loudest in their execrations of Hare and Burke, were themselves guilty of conduct almost as atrocious, which was nothing less than the endeavor to fasten the turpitude of these crimes upon the parties at the Medical School who received the bodies. They were accused of being in collusion with Hare and Burke, of conniving at their villainy, and paying them the wages of murder. Dr. Knox, who was at the head of the establishment, was held responsible, and accused of being the prime mover of the dark transactions.

Yet Dr. Knox never saw Burke and Hare but twice during the whole time that they were bringing subjects to the institution, and never had any thing whatever to do with them. The subjects were received in the usual way by persons in charge of the dissecting-room, and they constituted less than one-sixth of the regular supply of the establishment. Moreover, the practice of obtaining subjects in the way they were alleged to come had been long pursued. Tramps, vagabonds, beggars, and worthless, homeless creatures of all sorts were dying in the hovels, dens, cellars, and gutters, with nobody to claim them, and even their relatives, if they had any, would often sell their bodies for a few bottles of whiskey. It was frequently necessary in crowded lodgings to have bodies promptly removed, and there was a regular business done with the medical colleges in smuggling this class of subjects into their rooms. Hare and Burke were therefore doing nothing apparently unusual or that in itself excited suspicion. The porter of the establishment received the bodies, deposited them in the mor-

tuary, and then reported to the assistants, who were young medical students, without long experience. It was alleged that the bodies were brought fresh and warm, which was proof enough of the way they had been obtained. But this was by no means a necessary conclusion. Some of Burke's contributions were fresh, which created surprise; but he made no secret that he was in league with the relatives of the deceased or the owners of lodging-houses, for the prompt possession of bodies as soon as life was extinct. "When his attention was drawn to two apparently newly dead, his glib tongue and plausible statement served his purpose so well as to lull all doubts. One of these bodies was warm, on touching which the assistant expressed himself much horrified. Burke, being challenged in the strongest terms, admitted the warmth, for the person died only a few hours previously, and for secrecy the body had been in close contact with the fireplace. His open manner and ready excuse, when so boldly taken to task, told strongly in favor of the accuracy of his statement."

To illustrate the facility with which irregular practices might be carried on without public interference, Dr. Knox's biographer remarks: "There are no coroners' inquests in Scotland. Sudden death of either stranger or citizen does not concern the public authorities, unless suspicion is entertained and evidence can be offered to warrant the attention of the procurator-fiscal, who then makes a most thorough investigation in private, untrammeled by stupid juries and the comments of the press." He adds: "With the exception of Episcopalians and Roman Catholics, there is no burial service, either at the church or at the grave-side, in Scotland. In lieu of this, a minister attends the funeral, who offers a prayer or makes an address by the side of the bier at the house of the deceased." This gave rise to mock or sham ministers. Hypocritical wretches palmed off their services in many cases among the poor and ignorant to conduct funerals, and managed them so as to play into the hands of the body-snatchers.

The history is a peculiar one, and would require a volume to trace its complications. But the main fact about it is, that the doctors stood in peculiar relations, which exposed them to public animosity, and put them to every disadvantage, when the most extravagant and futile charges were made against them. A revolting and inhuman crime had certainly been committed, and the Medical School had the benefit of it. The conclusion that the head of the school had instigated it was easy to draw, especially if there was the slightest inclination of unfavorable feeling toward him.

Dr. Knox had therefore now to pay the penalty of his popularity. There was a vast mass of indignant and exasperated feeling in the university ready enough to be hostile, and easily turned in the direction of accusation and reprobation. The enemies of Dr. Knox, those who had been irritated by his comments, and those who were jealous of his influence, seized the opportunity to pay him off. It mattered

little that there was neither evidence nor shadow of evidence of the charge: it was only necessary to link Dr. Knox's name with the atrocities, and reasons enough would be found for the belief that he was the cause of them. If it appeared incredible, the reply was, that the villainies had actually been perpetrated by *somebody*, then why not instigated by him who had the greatest interest in the result? Besides, he was none too good for it, as judged out of his own mouth. Had he not replied to a medical student, when asked how he came to have so many Kaffre skulls in his museum: "Why, sir, there was no difficulty in Kaffraria; I had but to walk out of my tent and shoot as many Kaffres as I wanted for scientific and ethnological purposes." A passing joke was thus tortured into proof of a murderous disposition, and had its numerous believers. Again, Dr. Knox had said that "he could always command subjects." To which it was rejoined, "We now know what he meant—the West Port villains were in his pay." Thus by insinuation, perversion, and hinted suspicion, on the part of those who ought to have known better, and by a gaping credulity on the part of the mass of the people, the charges against Dr. Knox came to be believed by bare force of reiteration and association of ideas. The following specimen of the literature of the time embodies the whole logic of the case:

"Down the Close, and up the Stair,
But and Ben wi' Burke and Hare.
Burke's the butcher, Hare's the thief,
Knox the man that buys the beef."

On no better grounds than this Dr. Knox was condemned by the press, slandered by his medical brethren, denounced by the clergy, and his life was sought by the mob. Relying upon his entire innocence, abhorring the crime that had been done as much as anybody, and deeply indignant at the charges that were brought against him, Dr. Knox preserved silence. We can now appreciate the dignity and self-respect which impelled him to this, but he calculated wrongly for himself. Silence cannot be comprehended by a stupid public or a clamorous mob. The people were infuriated that he had not been indicted along with the West Port murderers, and Knox had to bear the whole weight of the city's wrath, which was increased by covert enemies in every quarter, and still further heightened by the escape of Hare. "Two months after Burke's condemnation, and his confession exonerating Knox from all blame whatsoever had been given to the world, *Blackwood's Magazine*, in its 'Noctes Ambrosianæ' (March, 1829), written by John Wilson, Professor of Moral Philosophy in the University of Edinburgh, *alias* Christopher North, made every effort to blast the character of the anatomist. Literary ruffianism is too mild a term to apply to the foul words used by Wilson, who, not content with holding up Knox to public execration, rushed with the savagery of the war-whoop and tomahawk upon an unoffending

anatomical class, for showing an affectionate regard for their great teacher."

Dr. Knox could have brought his enemies to strict account, and obtained heavy damages for their foul libels, but he preferred the policy of forbearance, as he had that of silence, and to leave the matter to be determined when the excitement should cease. So he kept on steadily with his work. One night, when a large class had assembled to hear him, the proceedings were interrupted by the yells and threats of an outside crowd, so that the students became alarmed. Knox, perceiving the growing restlessness of the audience, paused, and remarked: "Gentlemen, you are disquieted by these noises, to which no doubt you attach a proper meaning. Do not be alarmed; it is my life, not yours, they seek. How little I regard these ruffians you may well judge, for, in spite of daily warnings, and the destruction of my property, I have met you at every hour of lecture during the session; and I am not aware that my efforts to convey instruction have been less clear or less acceptable to you." This statement was received with such cheers as never before rang through a class-room in Edinburgh; and, amid all his troubles and trials, he found his only solace in the approval and affection of his students.

Dr. Knox at length broke his long silence by a letter to the *Caledonian Mercury*, of which the following is a part:

"Sir: I regret troubling either you or the public with any thing personal, but I cannot be insensible of the feelings of my friends, or the character of the profession to which I have the honor of belonging. Had I alone been concerned, I should never have thought of obtruding on the public by this communication.

"I have a class of above 400 pupils. No person can be at the head of such an establishment, without necessarily running the risk of being imposed upon by those who furnish the material of their science to anatomical teachers; and, accordingly, there is hardly any such person who has not occasionally incurred odium or suspicion from his supposed accession to those violations of the law, without which anatomy can scarcely now be practised. That I should have become an object of popular prejudice, therefore, since mine happened to be the establishment with which Burke and Hare chiefly dealt, was nothing more than what I had to expect. But, if means had not been purposely taken, and most keenly persevered in, to misrepresent facts and to influence the public mind, that prejudice would at least have stood on right ground, and would ultimately have passed away, by its being seen that I had been exposed to a mere misfortune, which would almost certainly have occurred to anybody else who had been in my situation.

"But every effort has been employed to convert my misfortune into positive and intended personal guilt of the most dreadful character. Scarcely any individual has ever been the object of more systematic or atrocious attacks than I have been. Nobody acquainted with this place requires to be told from what quarter these have proceeded.

"I allowed them to go on for months without taking the slightest notice of them; and I was inclined to adhere to this system, especially as the public

authorities, by never charging me with any offense, gave the only attestation they could that they had nothing to charge me with. But my friends interfered for me. *Without consulting me*, they directed an agent to institute the most rigid and unsparing examination into the facts. I was totally unacquainted with this gentleman; but I understood that, in naming Mr. Ellis, they named a person whose character is a sufficient pledge for the propriety of his proceedings.

"The result of his inquiries was laid before the Dean of Faculty and another counsel, who were asked what ought to be done. These gentlemen gave it as their opinion that the evidence was completely satisfactory, and that there was no want of actionable matter, but that there was one ground on which it was my duty to resist the temptation of going into a court of law. This was, that the disclosures of the most innocent proceedings even of the best-conducted dissecting-room must always shock the public, and be hurtful to science. But they recommended that a few persons of undoubted weight and character should be asked to investigate the matter, in order that, if I deserved it, an attestation might be given to me, which would be more satisfactory to my friends than any mere statements of mine could be expected to be.

"After a severe and laborious investigation of about six weeks, the result is contained in the following report, which was put into my hands last night. . . .

"Candid men will judge of me according to the situation in which I was placed at the time, and not according to the wisdom which has unexpectedly been acquired since. This is the very first time that I have ever made any statement to the public in my own vindication, and it shall be the last. It would be unjust to the authors of the former calumnies to suppose that they would not renew them now. I can only assure them that, in so far as I am concerned, they will renew them in vain."

The report here referred to bore the names of Sir John Robinson, chairman; Mr. M. P. Brown, advocate; Prof. James Russell, Dr. Alison, Sir George Ballingall, Sir George Sinclair, Sir William Hamilton, and Mr. Thomas Allen, banker; and completely and absolutely exonerated Dr. Knox from the charges that had been made against him. The public advocate went to the bottom of the case, and declared that there was no ground of suspicion; and one of the ablest representatives of the British bar, Lord Cockburn, who had a personal knowledge of all the facts, wrote in the "Memorials of his Time" as follows: "All our anatomists incurred a most unjust and very alarming though not unnatural odium; Dr. Knox in particular, against whom not only the anger of the populace, but the condemnation of the more intelligent persons, was specially directed. But, tried in reference to the invariable and the necessary practice of the profession, our anatomists were spotlessly correct, and Knox the most correct of them all."

Dr. Knox was a man of pluck, and he went along about his business, paying little attention to the storm of abuse and vituperation that rained upon him. But the savage injustice of which he was a victim was, nevertheless, not without its effect. It clouded his prosperity, darkened his life, and gave a cynical turn to his disposition.

His biographer remarks: "Only once, as far as I can learn, did Knox exhibit any emotion on account of the connection of his name with the Burke and Hare atrocities, and his freely-alleged complicity in the transaction. Walking in the meadows at Edinburgh with his old friend Dr. Adams, their conversation turned upon 'outward form and its relation to inward qualities.' Knox had a keen appreciation of the beautiful in form; and it chanced at the moment that a pretty little girl, about six years of age, caught his notice while at play. She afforded a text for Knox's comment on physical beauty, combined with unusual intelligence, in so young a child, for by this time he had drawn her into a playful conversation. At length he gave her a penny, and said: 'Now, my dear, you and I will be friends. Would you come and live with me if you got a whole penny every day?' 'No,' said the child; 'you would, maybe, sell me to Dr. Knox.' The anatomist started back with a painfully stunned expression; his features began to twitch convulsively, and tears appeared in his eyes. He walked hastily on, and did not exchange words with Dr. Adams for some minutes; at length came a forced laugh, with a questionable emphasis on the words '*vox populi*,' which led to a new topic of discourse."

Dr. Knox gave up his lectures in Edinburgh in 1839, and afterward went to London, where he died, December 20, 1862.

## TEMPERED GLASS.

By PERRY F. NURSEY, C. E.

A CONSIDERABLE degree of well-merited attention has of late been directed toward an invention which may be justly termed remarkable, even in these days of startling discoveries, inasmuch as it is one which promises to effect a complete change in the physical character of glass. This invention is the toughening process of M. François Royer de la Bastie, by which the natural brittleness of ordinary glass is exchanged for a condition of extreme toughness and durability. And this invention is perhaps the more remarkable in that it does not emanate from one engaged in, or practically conversant with, the manufacture of glass; nor is the discovery due to one of the great lights of science of our day; neither was it the result of a happy momentary inspiration. On the contrary, M. de la Bastie is a French private gentleman of fortune, residing in his native country—who, however, is given to the study of scientific matters. He was educated as an engineer, but his position and means rendered it unnecessary for him to follow the profession into which he had been initiated. He, however, is fond of experimenting in matters relating to engineering, and among

other things he, some years since, conceived the idea of rendering glass less susceptible to fracture, either from blows or from rapid alternations of heat and cold. The early training of his mind naturally led him to look to mechanical means for the accomplishment of this end; and he, in the first place, set himself a purely mechanical problem to solve. He thought—as did Sir Joseph Whitworth with regard to steel—that by submitting glass when in a soft or fluid condition to great compressive power, he should force its molecules closer together, and, by thus rendering the mass more compact, the strength and solidity of the material would be greatly increased. This was not an unreasonable line of argument, inasmuch as the fragility of glass results from the weakness of the cohesion of its molecules. Success, however, did not follow experiment, and the mechanical problem was laid aside unsolved.

M. de la Bastie, however, continued to regard the question from an engineering point of view, and turned his attention to another method of treatment. Aware that the tenacity of steel was increased and that a considerable degree of toughness was imparted to it by dipping it, while hot, into heated oil, he experimented with glass in a similar manner. The results were sufficiently successful to encourage him to persevere in this direction, and, by degrees, to add other fatty constituents to the oil-bath. Improved results were the consequence; and they continued to improve until at length, after several years of patient research and experiment, De la Bastie succeeded—with a bath consisting of a mixture of oils, wax, tallow, resin, and other similar ingredients—in producing a number of samples of glass which were practically unbreakable. As may be supposed, there were other conditions upon which success depended besides the character and proportions of the ingredients constituting the bath. M. de la Bastie, not being a glass-manufacturer, purchased sheets of glass, as well as glass articles, which he heated in a furnace or oven, to a certain temperature, and transferred to the oleaginous bath, which was also heated to a given temperature. These questions of relative temperature, therefore, had to be worked out; and De la Bastie had further to determine, very precisely, the condition of the glass most favorable for the proper action of the bath upon it. This he found to be that point at which softness or malleability commences, the molecules being then capable of closing suddenly together, thus condensing the material when plunged into a liquid at a somewhat lower temperature than itself, and inclosing some portion of the constituents of the bath in its opened and susceptible pores. Having determined all these conditions, and constructed apparatus, M. de la Bastie was enabled to take ordinary glass articles, and pieces of sheet-glass, and to toughen them so that they bore an incredible amount of throwing about and hammering without breaking. Just, however, as De la Bastie had perfected his invention, he lost the clew to success, and for two years he

was foiled in every attempt to regain it. There was the hard fact staring him in the face, that he had succeeded in depriving glass of its brittleness, as shown by specimens around him; but there was the harder fact before him, that he had lost the key of his success. Nevertheless he labored on, and at the end of the period above mentioned he had the satisfaction of finding all his anxieties at an end; his toils were requited by the rediscovery of his secret. He has since worked at it most assiduously, and has now brought it into practical working order, rendering the process as certain of success as any in use in the arts and manufactures in the present day.

As already observed, M. de la Bastie is not a glass-manufacturer; he therefore had to reheat glass articles when toughening them. It, however, by no means follows that the toughening process cannot be applied in the course of manufacture, thus avoiding reheating. On the contrary, it not only can be, but has been, applied at glass-works to glass just made, and so saves the costly and time-absorbing process of annealing. But, for reasons stated, M. de la Bastie had to apply the process to the manufactured article; and the method adopted, and the apparatus used in its application, next merit attention. In the first place, the glass to be toughened had to be raised to a very high

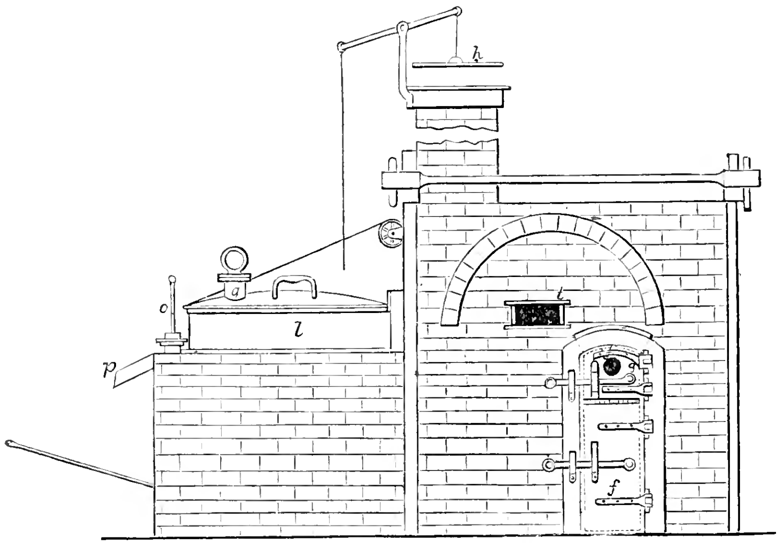



Fig. 1.

temperature—the higher the temperature the better—the risk of breaking the glass being thereby reduced, and the shrinkage or condensation being increased. It was therefore advantageous, and often necessary, to heat the glass to the point of softening; but in that condition glass articles readily lost their shape, and had to be plunged into the

bath almost without being touched. Then came another difficulty—that of preventing an already highly-heated combustible liquid taking fire upon the entrance of the still more highly-heated glass. The latter difficulty was met by placing the tempering bath in direct communication with the heating oven, and inclosing it so as to prevent access of air; and the former by allowing the heated glass articles to descend quickly by gravitation, from the oven to the bath.

The apparatus used by M. de la Bastie is shown in the accompanying illustrations, in which Fig. 1 is a front view, and Fig. 2 a vertical section, of furnace for annealing glass objects; Fig. 3 a sectional plan of the oven for annealing flat plates. The working oven, *a*, is heated by a furnace, *b*. The bottom of the oven, *c*, and the slope to the bath, are made in one piece of refractory material, and are very smooth on the surface. At the side of the oven is a preparatory oven, communicating by a passage in the separating wall. In this oven the glass is partially heated before being placed in the main oven, *a*. The products of combustion are carried away in the direction of the arrows through the chimney. When the oven, *a*, is sufficiently heated, the ash-pit and fire-doors are closed, and rendered air-tight by luting,

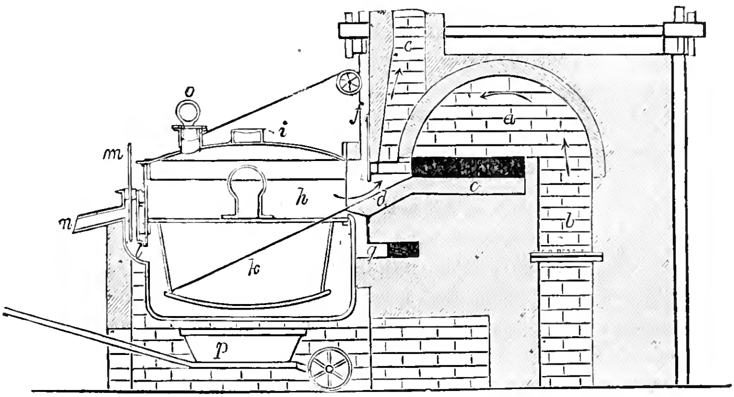



FIG. 2.

and the fire is maintained by small pieces of fuel introduced by a hole in the fire-door. The draught is then stopped by lowering the chimney-cap, or closing the damper. The vertical damper, *f*, is then raised, so that the flame passes by the flue, *g*, to a second chimney, passing thus along the slope and heating it, and also opening communication from the oven, *a*, to the bath, *h*, which is filled with the oleaginous compound. It is covered from the external air by a lid, and within it is a basket of fine wire gauze, *k*, hung from brackets. A tube, *l*, contains a thermometer, *m*, to indicate the temperature; and by this tube the contents of the bath may be added to, or any excess may overflow by the discharge-pipe, *n*. A plug, *o*, on the cover may be removed to

observe the interior, without entirely uncovering the bath. A fire-truck, *p*, charged with live fuel, heats the bath to the desired temperature. The glass is introduced into the preparatory oven by an opening in the outer wall, and thence it is moved through a second opening on to the floor of the oven, *a*. The workman who watches the glass through a spy-hole, when he finds it at the proper heat, pushes it by an iron rod to the slope, *d*, whence it slides into the bath and is received on the basket, *k*. When the glass has cooled to the temperature of the bath, the lid is removed, and the basket, *k*, is raised out of the bath with the tempered glass.

In tempering sheet-glass the arrangements of both oven and bath are slightly modified, as shown in Fig. 3. In place of the sloping exit

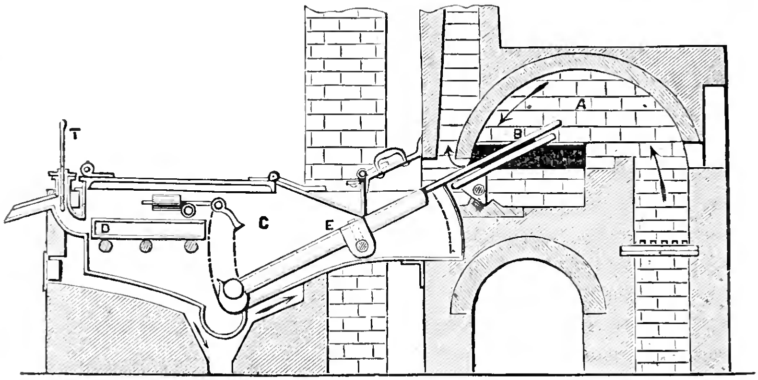



FIG. 3.

for articles from the oven to the bath, M. de la Bastie has a rocking table, E, which is hinged underneath to the mouth of the oven, and which also forms the floor of the oven. When the glass has been sufficiently heated, the workman, by means of a lever, tilts the table, and the glass slides gently down an easy incline on to a table set at a corresponding incline in the bath. If it is not of importance that the transparency of the glass should be preserved, no special precautions are taken to prevent the dust from the furnace settling on its face. Where, however, clearness is required, the glass is heated in a muffle, perfect transparency being obtained. The process of tempering or toughening, exclusive of the time required for heating the glass, occupies but a minute or so, the glass being immersed in the bath and at once withdrawn and set aside to cool. The cost per article, as may be supposed, is merely nominal.

Glass which has been treated in this manner undergoes a physical transformation as complete as it is remarkable. Its appearance is in no way altered, either as regards transparency or color—if colored glass be so treated—and its ring or sound is not in any way affected.

It has, however, exchanged its distinguishing characteristic of extreme brittleness for a degree of toughness and elasticity which enables it to bear the impact of heavy falling weights and smart blows without the least injury. A great number of experiments have been made, the results of which fully corroborate this fact. From these it will suffice to select a few by way of illustration. Watch-glasses, which perfectly retain their transparency, have resisted every attempt to break them by crushing between the fingers, or by throwing them about indiscriminately on the bare floor. Glass plates, dishes, colored lantern-glasses, and the like, have been similarly thrown about by the handful, stood upon, and otherwise maltreated, but without the slightest injury accruing to them, except, perhaps, when a solitary specimen which had been imperfectly tempered got in with the rest. Experiments have also been carried out to ascertain the comparative strength of toughened and untoughened glass when submitted to bending stress. Here a number of pieces of glass, each measuring six inches in length, by five inches in breadth, and having a thickness of about one-fourth of an inch, were tried. Each sample in its turn was supported at the ends, and a stirrup-piece was hung upon the centre of the glass, a weight-rod hanging vertically from the under-side of the stirrup. With this arrangement applied to a piece of ordinary glass, the weight-rod was gradually loaded until a weight of 279 pounds was reached, when the glass broke. A piece of toughened glass of similar dimensions, similarly treated, did not give way until a strain of 1,348 pounds had been reached, and before it yielded a considerable deflection was produced in it, showing its elasticity. Had its strength been due to rigidity or inflexibility alone, it would not have assumed a curve before yielding to the pressure brought upon it.

Satisfactory as the above results may appear at the first glance, they will be seen upon reflection most inadequately to represent the relative strength of toughened and untoughened glass. It will be observed that the test applied was that of long-sustained and gradually-increasing pressure, which could rarely occur to glass articles in every-day use. Glass is subject to sudden, sharp blows, either from articles falling down on other substances or from extraneous bodies falling upon or being brought in contact with them. Hence it is clear that to obtain a true estimate of the new process, glass must be subjected to tests which fairly represent the conditions of the accidents to which it is ordinarily exposed. This estimate has been arrived at repeatedly by placing pieces of plate-glass in a frame and allowing weights to fall on them from given heights. One experiment from a number—and which was made publicly—will illustrate this test: A piece of ordinary glass, six inches long by five inches wide, and one-fourth of an inch thick, was placed in a small frame which supported the glass around its edges, and kept its under-side about half an inch from the floor. A four-ounce weight was dropped on it from a height of one

foot, and the glass was broken. A piece of toughened glass of corresponding dimensions was then placed in the frame and the same weight dropped upon it several times from a height of ten feet, but without fracturing the glass. An eight-ounce weight was then substituted, and repeatedly dropped upon the glass from the same height as before, and with the same result, no impression whatever being made upon it. The eight-ounce weight was then thrown violently upon it several times, but without damaging it. Its destruction, however, was finally accomplished by means of a hammer. Perhaps the most crucial test to which toughened glass could be put would be to let it fall on iron. This has been done, and in public too. A thin glass plate was dropped from a height of four feet on to an iron grating, from which it rebounded about one foot, sustaining no injury whatever.

As singular as any other feature presented by toughened glass are the results of its destruction. Ordinary glass, upon being fractured, gives long, needle-shaped, and angular fragments. Not so toughened glass, which is instantaneously resolved into mere atoms. The whole mass is at once disintegrated into innumerable pieces, ranging in size from a pin's-point to an eighth of an inch in diameter. It sometimes occurs that pieces measuring half an inch or an inch across may remain whole, but these pieces are traversed in all directions by a net-work of fine lines of fracture, and with the fingers are easily reduced to fragments. Microscopical examination shows the fragments of toughened glass—large and small—to follow the same law as regards the form and character of the crystals, and on some of the larger crystals being broken up they have been found to separate into smaller ones of the same character. The edges of these fragments, too, are more or less smooth instead of being jagged and serrated as are those of fragments of ordinary glass. Hence a diminished tendency in the former to cause incised flesh-wounds when handled.

When glass has been imperfectly treated, as has sometimes happened in M. de la Bastie's experiments, it will not stand the same amount of rough usage as will perfectly-toughened specimens. The fact of the toughening process having been incomplete is made manifest upon the destruction of a sample in three different ways chiefly. Independently of its yielding at an early stage either to blows or pressure, it will show upon destruction either needle-fractures approaching in appearance those of ordinary glass, or pieces varying from the size of a sixpence to that of a half-crown will remain unbroken and untraversed by lines of fracture. Again, the mass may be wholly fractured, but on looking at the fragments edgewise a narrow, milky streak will be apparent midway between the upper and under sides of the glass, indicating that the influence of the bath has not extended through the glass. Where the process has been perfectly applied, no such phenomena are exhibited, the crystals being of uniform transparency throughout the whole mass.

Such, then, is De la Bastie's toughened glass, which possesses enormous cohesive power, and offers great resistance to the force of impact. There is, however, one peculiarity which, for the present, tells against it in a slight degree—it cannot be cut through with a diamond. Scratched its surface can be, but there the action of the diamond ceases. This drawback only applies in the case of window-glass in odd-sized frames; for the practice of the present day, with builders, is to make window-sashes of certain fixed dimensions, and glass-manufacturers work to these dimensions. It is not at all improbable, however, that ere long a means will be divised for cutting toughened glass to any size or shape; experiments are, in fact, now being conducted with this view, and so far as they have gone they give promise of success. But if toughened glass cannot be cut by the diamond, it can be readily cut and polished by the wheel, as for lustres and the like, so that wine-glasses and articles of cut glass-ware can be toughened directly they are made, and cut and polished subsequently.

Superficial observers have affected to detect in the toughening process a similar condition of matter to that which obtains in Prince Rupert's drops. The error of such a conclusion, however, becomes evident upon a little consideration. Prince Rupert's drops are made by allowing melted glass to fall into cold water; the result of which is a small pear-shaped drop, which will stand smart blows upon the thick end without injury; but the moment the thin end, or tail, is broken, the drop flies into fragments. Now, glass and water, and—as far as present knowledge goes—no other substances besides, expand while passing from the fluid into the solid condition. The theory of the Rupert drops is, that the glass being cooled suddenly, by being dropped into cold water, expansion is checked by reason of a hard skin being formed on the outer surface. This exterior coating prevents the interior atoms from expanding and arranging themselves in such a way as to give the glass a fibrous nature, as they would if the glass was allowed to cool very gradually. An examination of the Rupert's drop shows the inner substance to be fissured and divided into a number of small particles. They exist, in fact, in a state of compression, with but little mutual cohesion, and are only held together by the external skin. So long as the skin remains intact the tendency of the inner particles to expand and fill their proper space is checked and resisted by the superior compressive strain of the skin. Nor is the balance of the opposing forces disturbed by blows on the thick end of the drop, which vibrates as a whole, the vibrations not being transmitted from the exterior to the interior. But by breaking off the tail of the drop a vibratory movement is communicated along the crystalline surface, admitting of internal expansion, by which the cohesion of the particles composing the external skin is overcome, and the glass is at once reduced to fragments. As the skin of toughened

glass can be cut through with the diamond, and as, moreover, its surface can be removed by polishing and cutting with the wheel, without injury to the mass, it is evident that it must exist under conditions very dissimilar from those of a Rupert's drop. Moreover, melted glass, on being dropped into De la Bastie's bath, gives a similarly shaped body, from which the tail can be broken off, piece by piece, without injury to the body, which can be scratched, knocked and thrown about, without exhibiting any signs of deterioration. Bearing upon this point, too, comes the fact that toughened glass can be elegantly engraved, either by Tilghman's sand-blast process, or by means of hydrofluoric acid, in the ordinary way, the surface or outer skin being thus removed.

M. de la Bastie's invention marks a distinct era in the history of one of our most important industries. Never during the history of glass-manufacture, which extends over some 3,500 years, has any radical change been effected in its character. The glass-blowers of Egypt, who practised their art before the exodus of the children of Israel, and representations of whom have been found on monuments as ancient as that event, produced a similar glass to that of our own times. This has been proved by an examination of glass ornaments which have been discovered in tombs as ancient as the days of Moses. It has been proved, too, by a large bead of glass, found at Thebes, upon which was inscribed the name of a monarch who lived 1,500 years B. C., and which glass was of the same specific gravity as our own crown-glass. It is true Pliny mentions that a combination was devised in the reign of Tiberius, which produced a flexible glass; but both the inventor and apparatus were destroyed, in order, it is said, to prevent the value of copper, silver, and gold, from becoming depreciated. There is, however, no evidence whatever that this was the toughening process of De la Bastie, nor does the record in any way detract from the merits of that gentleman as the inventor of an important economic process. The fact remains that the world has now given to it for the first time, in a practical form, an invention by which the brittleness of glass is superseded by an attribute of the most valuable nature—toughness. It is by no means improbable that the old adage, "as brittle as glass," will soon be superseded by a new one —"as tough as glass."

What may be the ultimate result of the introduction of this invention in practice it is difficult to foresee, so wide-spread, so universal does its application seem. Not only is it desirable to render durable such articles as are at present made from glass, but to satisfy a want long felt in every department of art, science, and manufacture, of such a material as toughened glass; and this want can now be satisfied. So numerous are the opportunities which present for its application, and so well adapted does it appear to be where cleanliness, transparency, resistance to heat and chemical action, and comparative in-

destructibility are desiderata, that it would be idle to attempt to categorize them.

The invention is being taken up practically on the Continent, and no less in England. Messrs. Powell, of Whitefriars, are introducing it in their glass-works, and two other firms in the north of England are doing the same. It is by no means improbable that its first introduction in practice in this country will be at the aquarium now in course of erection at Westminster, where it is intended to use it for the tanks.

There still remain some questions to be answered with regard to the phenomena exhibited by toughened glass—questions, however, which in no way affect the practical value of the material. Its peculiarities continue to form the subject of investigation, and, as soon as any conclusions of value to science have been arrived at, they will be made known, so that the physical aspect of toughened glass may again be reverted to in these pages. It only remains to observe that the remarkable character and unique nature of M. de la Bastie's invention are such as to render it probable that he will not only materially benefit those of his own time, but will bequeath to posterity an invaluable legacy.—*Popular Science Review.*

## FRESH-WATER MOLLUSKS.[1]

By Prof. EDWARD S. MORSE.

UNDER lily-pads and on the stems and leaves of other aquatic plants, and on stones in rivers, snails of various kinds will be found. A dipper with the bottom perforated, or made into a sieve, and attached to a wooden handle four or five feet in length, will be

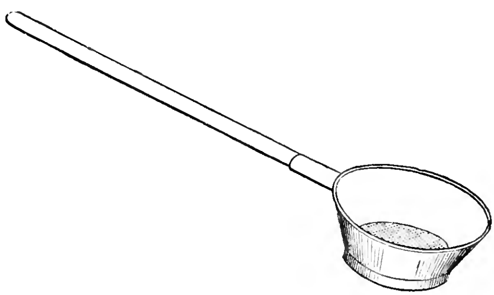


Fig. 1.—Dipper attached to a Wooden Handle for collecting Snails.

found useful in scooping up the sand or mud from the bottom of rivers and ditches. The dirt having been sifted out, the shells and other

[1] From "First Book of Zoölogy," now in press of D. Appleton & Co.

objects will be left behind. The dipper may be made as seen in Fig. 1.

Shells collected with the snails inside, and cleaned for the cabinet, are called *live shells*. They are always more fresh and perfect than dead shells. Having made the collection, the snails should be kept alive in a wide-mouthed jar, or bottle, care being taken not to have more than fifteen or twenty in a jar holding a quart of water.

Some of the following forms will have been secured:

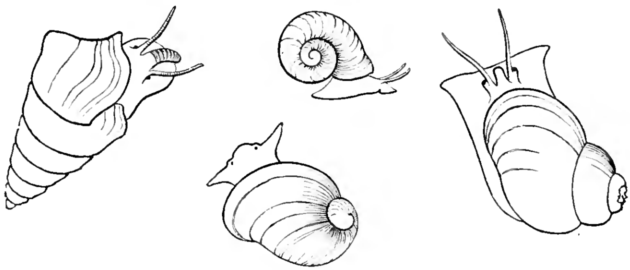


Fig. 2.—Fresh-Water Snails.

The broad, creeping disk upon which the snail rests, and by which it retains its hold to the glass, is called the *foot*. The snail moves about, and crawls or glides slowly along, by means of the foot.

The two little horns or feelers, in front, are called *tentacles*, and, as the snail moves, the tentacles are seen stretched out in front, and occasionally bending, as if the creature were feeling its way along. The eyes are seen at the base of the tentacles, as two minute black dots. The mouth is between the tentacles, and below. The part from which the tentacles spring is called the *head*, and the opposite end of the body is called the *tail*. The surface upon which the snail rests is called the *ventral* or lower surface, and consequently that portion of the body which is above is called the *dorsal* surface, or back.

In watching the habits of the snails he has collected, the reader will notice some of them crawling to the surface of the water to breathe air. The snail accomplishes this by raising the outer edge of the aperture to the water's edge, and then opening a little orifice in the side, through which the air enters to the simple lung within. This orifice is on the right side in those snails having dextral or right-handed shells, and on the left side in those snails having sinistral or left-handed shells.

Many kinds of snails which live in fresh water are called air-breathers, because they are forced to come to the surface of the water to breathe air. In doing so they first expel a bubble of air, which may be seen escaping from the breathing-orifice, as in Fig. 4, *B*.

These fresh-water air-breathing snails may be kept under water for many hours before life is extinct.

Among the snails collected, there will probably be found some which have a peculiar scale on the hinder part of the body. When the snail crawls, this scale will be seen just behind the shell, as in

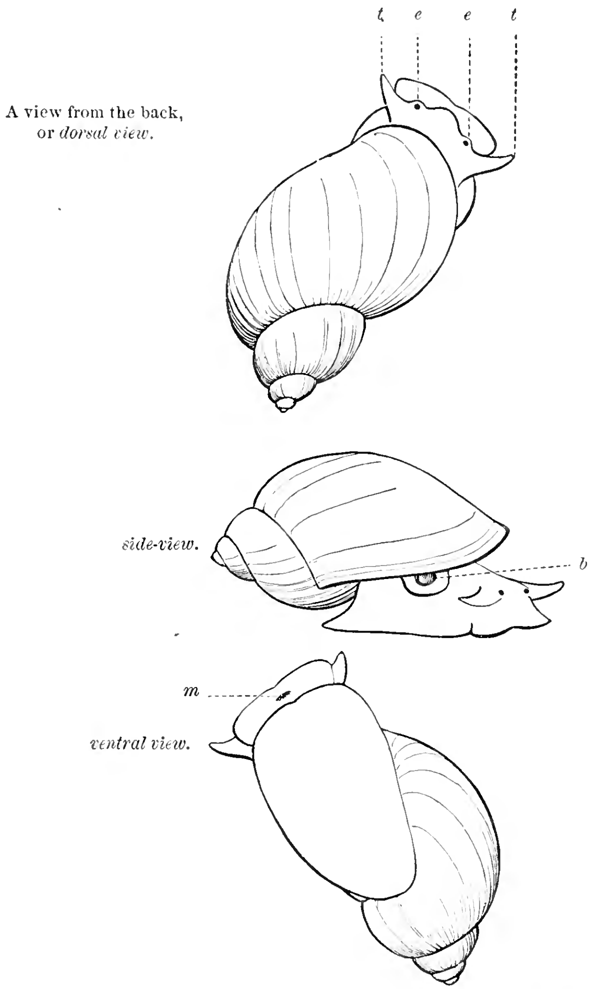



FIG. 3.—A FRESH-WATER SNAIL SEEN FROM ABOVE, FROM THE SIDE, AND FROM BELOW. *t t*, Tentacles; *e e*, Eyes; *b*, Breathing-orifice; *m*, Mouth.

Fig. 5, *o*. This scale is called the *operculum*, and when the snail has contracted, or drawn within the shell, the operculum is seen to fit the aperture of the shell, closing the shell as a stopper closes the mouth of a bottle.

Nearly all sea-snails, that is, snails which live in salt-water, and many species of fresh-water snails, and also many snails which live in damp places on the land, and which are called land-snails, have an

operculum. When the snail has retired within the shell, the operculum will look like this in the aperture of the shell (Fig. 6): A series of concentric lines will be seen marking the operculum, and these are the lines of growth, the operculum growing around the outer edge by successive additions, just as the shell grows by successive additions to its outer margin.

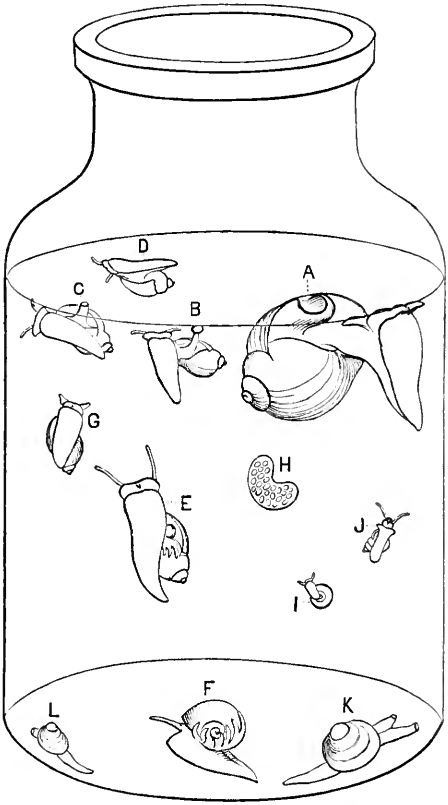



Fig. 4.—Jar of Water, in which is contained a Number of Species of Mollusks. Some of them are near the Surface breathing Air:

*A* and *C* are taking in air; *B* is just expelling a bubble of air from the lung; *D* is crawling on the surface of the water; *E*, *G*, and *I*, are in the act of crawling up, to get a fresh supply of air; and *J* is a water-breather, having gills, but no lung.

The Western rivers teem with species of snails having opercula.

If the pupil has any of these operculated snails alive, he will observe that they do not come to the surface to breathe air. Instead of a lung, they have a cavity containing an organ, or part, called the gill, by means of which the snail is capable of getting from the water what the air-breathing snail gets from the air, namely, *oxygen*. It will be seen that the head of the snail is shaped differently in the snails having an operculum, the mouth being at the end of a sort of

proboscis or *rostrum.* (*See* Fig. 5.) The shells, too, are, as a general thing, more solid.

Thus far we have examined those snails which live in fresh water. Some of these were air-breathers, and came to the surface of the water

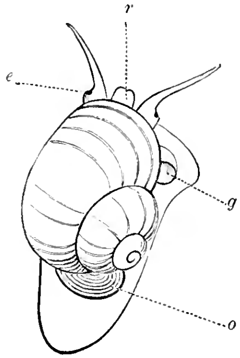



Fig. 5.—Snail with Operculum.
*o*, Operculum; *e*, Eye; *r*, Rostrum; *g*, Entrance to Gill-Cavity.

at intervals to breathe air. We have studied other fresh-water snails which did not breathe air directly, but performed this function by means of an organ called the gill. And these snails were operculated, that is, they all possessed a little scale called the operculum, which closed the aperture tightly when the snail contracted within the shell.

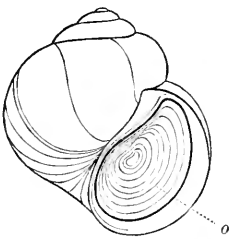



Fig. 6.—Aperture of Shell closed by Operculum, *o*.

We have also learned that the shells grow in size by successive additions of limy matter deposited around the free border of the aperture, and that the delicate lines which mark the surface of the shell, and which run parallel to the outer edge of the aperture, are lines of accretion, or lines of growth.

Looking over our fresh-water shells again, we find many that are known as muscles, or clams. These shells are common everywhere along the margins of brooks, rivers, and lakes. The musk-rats feed upon the soft parts of the muscles, and the remains of their feasts may be found in piles of mussel-shells all along the shores of certain lakes. The shell is composed of two pieces, or *valves*, as they are called.

The two valves are often found united, and the margin along which they are connected is called the *hinge-margin*, because the shells hinge at this part, and will open and shut as a door swings upon its hinges.

Let the pupil now examine a perfect fresh-water mussel, that is, a mussel in which the valves are united in this way, and he will observe that they are connected by a brownish substance, which is quite elastic when the shell is alive, but becomes brittle when dried. The shells are held together as the covers of a book are held together by the back. This substance is called the *ligament*, and the position of this ligament will indicate the back, or *dorsal region* of the animal.

On the outside of the shell will be seen fine lines, which run nearly parallel to the outside margin of the shell. These lines are the *lines of growth*, and indicate the successive stages of growth, or increase of the shell, as in the lines of growth in the snail-shell already studied, and, as in the snails, the growth takes place at the margin of the shells.

We may trace these concentric lines back, as they grow smaller and smaller, till they are found to start from one point at the back of the shell, and this point is called the *beak* or *umbone*. It represents the starting-point in the growth of the shell. In fresh-water mussels, the umbones are eaten away by some corrosive action of the water, and the early stages in the growth of the shell are usually destroyed. In very young shells, however, the early stages can be plainly seen.

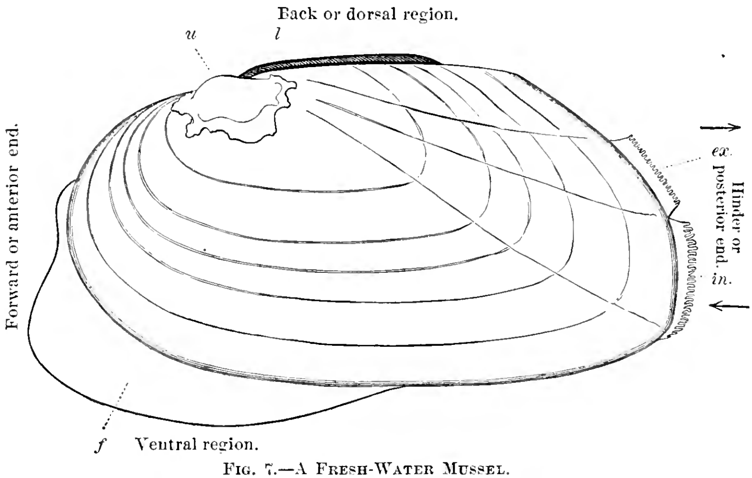



FIG. 7.—A FRESH-WATER MUSSEL.
*l*, Ligament; *u*, Umbone; *f*, Foot; *ex.*, Excurrent Orifice; *in.*, Incurrent Orifice.

The ligament is always behind the beak, or umbone, in fresh-water mussels, and in nearly all *bivalve* shells (so called, because they have two valves or pieces, while the snail-shells are sometimes called *univalve* shells, because they have but one valve or piece).

Now hold a perfect mussel-shell in your hand (that is, a mussel in which both valves are together, and united across the back), with the ligament uppermost, and the umbone away from the person, or beyond the ligament, and the valve on the left hand is the one which covers the left side of the animal, while the valve on the right hand covers the right side of the animal. The forward end will be the end away from the person, and the hinder end will, of course, be the end toward the person. (*See* Fig. 7.)

Let us now endeavor to collect some fresh-water mussels alive. These may be found partly buried in the sand or mud of rivers and lakes. As they crawl along partly buried in this way, they plough up the sand, leaving a well-marked furrow or groove behind them. Every boy that goes in bathing is familiar with the peculiar furrow left by the fresh-water mussel. By following such a furrow, the mussel that made it will soon be found.

Fig. 8 represents the appearance of a common fresh-water mussel in the act of crawling.

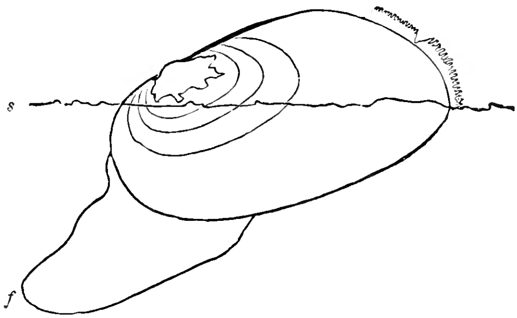



FIG. 8.—SHOWING POSITION OF MUSSEL WHEN CRAWLING.
*f*, Foot buried below the Surface of the Sand *s*. Above the line *s* is supposed to be water, the line representing the bottom of a lake or river.

Having collected a few in this way, they may be placed in a large, shallow pan of water, and allowed to remain quiet for a while. Gradually the shells will open a little, and from the hinder end a curious fringed border appears; on examining this border, it will soon be found that it forms two openings which lead into the shell.

Great care must be taken not to jar the dish, or the table upon which it rests. The slightest jar will cause the shells to instantly close. If some indigo, or small particles of dirt, be dropped near these openings, currents of water will be revealed; one current pouring out of the opening nearest the back, and another current as steadily pouring in at the other opening. The opening into which the current of water is passing is called the *incurrent orifice*, while the orifice from which a current of water is passing is called the *excurrent orifice*. The incurrent orifice is sometimes called the respiratory orifice, because the water is taken in to supply the gills which are the breathing or

respiratory organs of the mussel, and this orifice corresponds to the siphon in the sea-snails already studied. This current of water, besides bathing the gills, also carries in minute particles which are floating in the water, and these particles are conducted to the mouth of the creature, and swallowed as food. At the opposite end of the shell from these openings, or the forward end, a whitish, fleshy mass will be seen protruding. This is called the *foot*, and corresponds to the foot or creeping disk in the snails. By means of this foot the mussel crawls through the sand.

The mouth is above the foot, and always concealed within the shell. In Fig. 7 the foot is shown, and also the excurrent and incurrent orifices, with arrows drawn to indicate the direction of the currents of water.

In some small species of fresh-water bivalves, the excurrent and incurrent orifices are prolonged into tubes, and then they are called *siphons*. Fig. 9 represents a common species which the pupils may find in muddy brooks and ditches. By using the long-handled dipper already described, some specimens will probably be found. They are quite small, from the size of a pea to that of a nickel cent. The siphonal tubes are prominent, and the foot is long and tongue-shaped, and the animal is very active in crawling about; also in Fig. 4 *K* and *L* represent two of these small animals with bivalve shells.

Fig. 9.

The foot of these creatures resembles in appearance and action the foot of a fresh-water snail, only there is no mouth nor tentacles in sight. These parts are present, but are never protruded beyond the edges of the shell.

When the fresh-water mussels are partly open, a fleshy border will be seen just within the edges of the shell, and this is the border of the *mantle*, and corresponds to the same parts described in the snails; the fringed membrane which formed the openings at the hinder part of the mussel is simply a continuation of the mantle.

When the shells are removed from the animal, the mantle will be found lining the shells, just as the blank pages line the inside of a book-cover. While the edge of the mantle deposits the successive layers, which increase the size of the shell, the entire surface of the mantle deposits the pearly substance which lines the inner surface of the shells, and which is so characteristic of the fresh-water mussels.

Grains of sand, or other particles, getting in between the mantle and the shell, are soon covered by layers of pearly substance poured out, or secreted by the mantle. In this way pearls are formed.

If pearls are broken open, a centre, or nucleus, will be found, consisting of some particle of dirt or sand, or some substance which had found its way by accident between the mantle and the shell, and around which the pearly matter has been formed in successive layers.

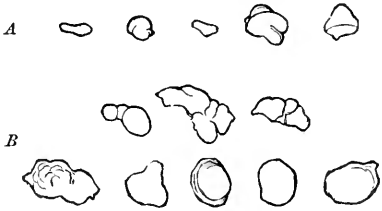


Fig. 10.—*A*, Pearly Concretions from a Fresh-water Mussel; *B*, Pearly Concretions from the Common Oyster.

In shells having a brilliant, pearly lining, or *nacre*, the pearls obtained are oftentimes very beautiful, and from certain Oriental species living in the sea, called *Avicula*, the most brilliant pearls of commerce are obtained. If, on the other hand, the nacre lining the shell is dull white, as in the common oyster, the pearls are dull colored. These kinds of pearls are often found in oysters.

The Chinese have long been familiar with the art of making artificial pearls. By partly opening the shells of certain fresh-water mussels, and inserting little lead images, or other objects, between the mantle and the shell, the objects soon become covered with a natural layer of pearl.

Let us now study the markings on the inner surface of the shells of river-mussels. The shells of these creatures are called *valves*, and are spoken of as right or left valves, according to whether they are on the right or left side of the animal.

Certain ridges and prominences will be seen at the hinge, and, when the valves are carefully joined, the ridges in one valve will correspond to grooves in the other valve. These ridges are called *teeth*. The short ones, near the beak, are called *cardinal teeth*, and the long ones *lateral teeth*. The margin upon which they occur is called the *hinge-margin*, for it is upon this margin that the valves turn. (*See* Fig. 11.)

Certain scars, or impressions, will be found marking the inside of the valves, and these indicate the point of the attachment of certain muscles to move the valves, and to enable the animal to protrude its foot, and crawl along. These marks are hence called muscular marks, or *muscular impressions*, and will be found to correspond in the right and left valves.

An irregular, round impression will be found at each end of the valve, near the hinge-margin. These show where the muscles are attached to move and close the valves, and hold them firmly together. The muscles run directly across from one valve to the other; and, to open a live mussel, it is necessary to pass a sharp blade between the

valves, and cut through the muscles, before the valves will open. These muscles are called the *adductor muscles*, and the scars or impressions on the valves are called the *adductor muscular impressions.* Very close to the adductor muscular impressions are seen smaller impressions, and these indicate where the muscles are attached which move the foot. These muscles are called the *pedal* muscles, and the impressions are called the *pedal muscular impressions.* One occurs just behind the anterior adductor impression; the other will be found just above, and in front of the posterior adductor impression.

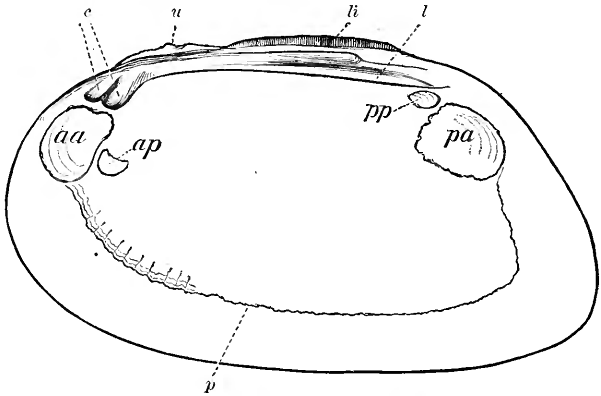



Fig. 11.—The Right Valve of a Fresh-Water Mussel.

*c*, Cardinal Teeth; *l*, Lateral Tooth; *li*, Ligament; *aa*, Anterior Adductor Impression; *pa*, Posterior Adductor Impression; *ap*, Anterior Pedal Muscular Impression; *pp*, Posterior Pedal Muscular Impression; *p*, Pallial Line; *u*, Umbone.

Besides these marks, we see a delicate and slightly irregular line running from the anterior to the posterior muscular impression, just inside, and nearly parallel with the lower margin of the shell. This line is called the *pallial line*, and indicates where the mantle is attached to the shell. It will be observed that, when the soft parts are removed from the shell, the mantle adheres along this line.

When the mussel is opened by separating the adductor muscles with a knife, the valves slowly open, and after the animal is removed the valves still remain partly open, and, to preserve them closed, a string has to be tied around them, and in this condition, if the ligament is allowed to dry, the valves will then remain closed. From this it is evident that the ligament acts upon the valves to draw them apart. To keep them closed, then, the animal must continually exert itself by contracting the adductor muscles; and it will be found that, when these creatures are left in the water, undisturbed for a while, the muscles relax, and the valves partly open. The ligament is elastic, and is stretched as it were from one valve to the other, over the back. A possible imitation of the action might be represented by partly opening the lids of a book, and then gluing across the back, from one lid to the other, a sheet of elastic rubber. If, now, the lids are tightly

closed, the rubber is drawn out, or stretched across the back, and, if allowed to regain its elasticity, the lids are pulled apart. This experiment illustrates the way in which the ligament acts in those shells which have the ligament external.

## THE DEEPER HARMONIES OF SCIENCE AND RELIGION.[1]

### III.

PUTTING aside, then, for the present, supernaturalism and all those views of God which are distinctively Christian, we find a theology in which all men, whether they consider it or not, do actually agree—that which is concerned with God in Nature. I do not here raise the question of causes or laws; let it be allowed that Nature is merely the collective name of a number of coexistences and sequences, and that God has no meaning different from Nature. Let all this be allowed, or let the contrary of this be allowed. Such controversies may be raised about the human as well as about the Divine Being. Some may consider the human body as the habitation of a soul distinct and separable from it; others may refuse to recognize any such distinction; some may maintain that man is merely the collective name for a number of processes; some may consider the human being as possessing a free-will and as being independent of circumstances; others may regard him as the necessary result of a long series of physical influences. All these differences may be almost as important as they seem to the disputants who are occupied about them, but after all they do not affect the fact that the human being is there, and they do not prevent us from regarding him with strong feelings. The same is true of the Divine Being. Whatever may be questioned, it is certain that we are in the presence of an Infinite and Eternal Being; except through some of those exceptional perversions of the mind which I described in the last chapter, we cannot help the awe and admiration with which we contemplate him; we cannot help recognizing that our well-being depends on taking a right view of his nature.

There are two ways in which the mind apprehends any object, two sorts of knowledge which combine to make complete and satisfactory knowledge. The one may be called theoretic or scientific knowledge; the other practical, familiar, or imaginative knowledge. The greatest trial of human nature lies in the difficulty of reconciling these two kinds of knowledge, of preventing them from interfering with one another, of arranging satisfactory relations between them. In order of time the second kind of knowledge has the precedence, and avails itself of this advantage to delay and impede the arrival of

[1] From a series of papers in *Macmillan's Magazine*, on "Natural Religion."

the first kind. Before the stars, the winds, the trees and plants, could be grasped scientifically, and the laws which govern them studied, they had been grasped, and as it were appropriated, by the human mind experimentally and imaginatively. The latter kind of knowledge was in some respects better than the former. It was more intimate and realized, so that, as far as it was true, it was more available. For practical purposes, accurate scientific knowledge of a thing is seldom sufficient. To obtain complete practical command over it you must take possession of it with the imagination and feelings as well as the reason, and it will often happen that this imaginative knowledge, helped very slightly by scientific knowledge, carries a man practically furthei than a very perfect scientific knowledge by itself. Witness the instinctive, as we say, and unanalyzable skill sometimes possessed by savages. Moreover, this kind of knowledge is more attractive and interesting, and so has a more powerful modifying influence upon its possessor, than the other kind, for the simple reason that it takes hold of the most plastic side of his nature. But just because it is so fascinating, and is at the same time not by itself trustworthy, it has certain mischievous consequences when it comes, as it generally does, first. Then it fills the mind with prejudices, hasty misconceptions, which, seizing upon the imagination, are stereotyped in the form of superstitions; and these sometimes exercise by themselves a most pernicious influence, and in any case close the mind against the entrance of the sounder scientific knowledge. When this imaginative medley of observation and prejudice has long had possession, science arrives. Then follows a contest between the two kinds of knowledge, in which the human being suffers much. Truth cannot in the long-run be resisted, and so, after whatever defense, the fortress is carried and the phantom garrison of superstition is driven out. The mind passes now under a new set of impressions, and places itself in a new relation to the universe. Its victory over superstition has been won by placing a careful restraint upon imagination and feeling. In order not to be misled by feeling, it has been forced artificially to deaden feeling; lest the judgment should be overwhelmed by the impressiveness of the universe, it arms itself with callousness; it turns away from Nature the mobile side, and receives the shock upon the adamantine shield of the skeptical reason. In this way it substitutes one imperfect kind of knowledge for another. Before, it realized strongly, if that expression is clear, but scarcely analyzed at all; now, it analyzes most rigidly, but ceases in turn to realize. As the victory of the scientific spirit becomes more and more decided, there passes a deep shudder of discomfort through the whole world of those whose business is with realizing, and not with testing, knowledge. Religion is struck first, because the whole work of *realizing* presupposes faith, and yet, as the testing process comes late, faith is almost always more or less premature. But poetry and art suffer in their turn. How

full has recent poetry been of this complaint! One poet complains that "science withdraws the veil of enchantment from Nature;" one exclaims that "there *was* an awful rainbow *once* in heaven," but that science has destroyed it; another declares that "we murder to dissect," that we should not be always seeking, but use "a wise passiveness" in the presence of Nature; another that "Nature made undivine is now seen slavishly obeying the law of gravitation;" another buries himself in past ages "when men could still hear from God heavenly truth in earthly speech, and did not rack their brains."

And yet to complain of the march of the scientific spirit seems as idle as to complain of the law of gravitation itself. Influenced, some by a deep faith in truth, a faith, I mean, that human well-being must depend ultimately on truth; others by a fanatical truth-worship, determined to set up their idol even "amid human sacrifice and parents' tears;" others by a scientific *esprit de corps* which hates religion as belonging to a rival corporation; others by that self-importance which is gratified by inflicting pain so much more than by giving pleasure; others by the tyrant's delight in having discovered a new and exquisite torture—influenced, in short, by all the mixed motives which have ever urged on a great destructive movement, the iconoclasts pursue their course. But we may look forward to a time when this transition shall be over, and when a new reconciliation shall have taken place between the two sorts of knowledge. In that happier age true knowledge, scientific, not artificially humanized, will reign without opposition, but, the claims of science once for all allowed, the mind will also apprehend the universe imaginatively, realizing what it knows.

That kind of imaginative eclipse which is produced by the shadow of science passing over any natural object has affected in turn the phenomena of Nature, taken separately, and man and God. The "fair humanities of old religion," which found objects of love in trees and streams, and filled the celestial map with fantastic living shapes —all this has long ago disappeared. More recently man has been subjected to the analyzing process. The mechanical laws which were traced in the physical world, it was long hoped, would never suffice to explain the human being; he at least would remain always mysterious, spiritual, sacred. But nothing stops science; hesitating between curiosity that drags him on and awe that holds him back, vexed not to know, yet half ashamed of knowing, man presses on into every sanctuary. He begins now to reckon his own being among things more than half explained; nerve-force he thinks is a sort of electricity; man differs greatly, indeed, but not generically, from the brutes. All this has for the time at least the effect of desecrating human nature. To the imagination human nature becomes a thing blurred and spoiled, not really because the new view of it is in itself degrading, but because the imagination had realized it otherwise, and cannot in any

short time either part with the old realizing or perfect a new one. Lastly, Science turns her smoked eye-glass upon God, deliberately diminishing the glory of what she looks at that she may distinguish better. Here, too, she sees mechanism where will, purpose, and love, had been supposed before; she drops the name God, and takes up the less awful name of Nature instead.

It is in this last case that the desecration produced by science is most painfully felt. This is partly, of course, because the sacredness violated was greatest here; but there is also another reason. Science cannot easily destroy our feeling for human beings. We are in such close contact with our own kind, our imagination and affections take such fast hold of our fellow-men, as to defy physiology. If it were otherwise we should want a word—*Ananthropism*—to answer to atheism. Even as it is the thing is occasionally to be seen. Among medical students there are not a few ananthropists, that is, men in whom human affections have not been strong enough to resist the effect of science in lowering the conception of humanity. But in general the imagination triumphs in this case over the reason. In the case of the physical world it is otherwise. This, for the majority of men, is, I fancy, almost completely desecrated, so that sympathy, communion with the forms of Nature, is pretty well confined to poets, and is generally supposed to be an amiable madness in them. But then this was not done by science, it had been done before by monkish Christianity. Chaucer complains, hundreds of years before the advent of physical science, of the divorce that had been made between the imagination and physical nature—"But now may no man see none elves mo." It was owing, according to him, to the preachings and bannings of "limitours and other holy frères." Nature had been made not merely a dead thing, but a disgusting and hideous thing, by superstitions of imps, witches, and demons; so much so that Goethe celebrates science as having restored Nature to the imagination and driven away the Walpurgisnacht of the middle ages; and, indeed, by turning attention upon the natural world, by bringing a large number of people to take careful notice of its beauties, science may have given back to the imagination, in this department, as much as it has taken away.

But the conception of God is so vast and elevated that it always slips easily out of the human mind. The task of realizing what is too great to be realized, of reaching with the imagination and growing with the affections to a reality almost too great for the one, and almost too awful for the other, is in itself exceptionally difficult. To do this, and yet at the same time carefully to restrain the imaginations and affections as science prescribes, is almost impossible; yet those who perpetually study Nature, unless they specialize themselves too much, will always in some sense feel the presence of God. The unity of what they study will sometimes come home to them and give a sense of

awe and delight, if not of love. But upon those who do not study Nature the advance of science can have no other effect than to root out of their minds the very conception of God. The negative effect is not counterbalanced by any positive one. With them, if the supernatural person whose will holds the universe together is denied, the effect is that the universe falls at once to pieces. No other unity takes his place, and out of the human mind there perishes the most elevating thought, and out of human life the chief and principal sacredness. The remedy for this is to be found in the study of Nature becoming universal. Let all be made acquainted with natural laws; let all form the habit of contemplating them, and atheism in its full sense will become a thing impossible, when no mind shall be altogether without the sense, at once inspiring and sobering, of an eternal order.

But these remarks on the difficulty of harmonizing the scientific with the imaginative knowledge of things, are by way of digression. Our business at present is with the fact that knowledge is of these two kinds, and that the complete or satisfactory knowledge of any thing comes from combining them. When the object of knowledge is God, the first kind of knowledge is called theology, and the second may be called religion. By theology the nature of God is ascertained and false views of it eradicated from the understanding; by religion the truths thus obtained are turned over in the mind and assimilated by the imagination and the feelings.

When we hear it said, as it is said so commonly now, that the knowledge of God is impossible to man, and therefore that theology is no true science, of course the word God is used in that peculiar sense of which I have spoken above. Nature every one admits that we know or may know; but of any occult cause of phenomena, or of any supernatural being suspending the course of natural laws, it is denied that we can know any thing. But since every sort of theology agrees that the laws of Nature are the laws of God, it is evident that in knowing Nature we do precisely to the same extent know God. I am proposing for the present to treat the words of God and Nature as absolutely synonymous, which up to a certain point every one allows them to be. So long as we do so we are in no danger of trespassing beyond the proper domain of human inquiry; so long as we do so, theology, instead of being additional or antagonistic to science, is merely another name for science itself. Regarded in this way, we may say of God, that so far from being beyond knowledge, he is the one object of knowledge, and that every thing we can know, every proposition we can frame, relates to him. It may seem, however, that little is to be gained from giving this unusual sense to the word theology. If in the ordinary sense it is the name of an imaginary and delusive science, taken in this sense as a synonym for science itself, it is purely useless. By giving the word such an extension, it will be said, you destroy all its force. That we ought to study theology be-

comes a truism if it means merely that all knowledge is valuable; the old maxim, that in the knowledge of God is life, loses all its grandeur if it is interpreted to mean merely that the more things you know the more dangers you will be in a condition to avoid. Can we not, then, give more precision, more definiteness, to the notion of the knowledge of God?

The notion is to be limited in two ways, one of which has been partially indicated already. The scientific school themselves save us the trouble of explaining the first of these limitations; it is they who, in this age, have made clear to every one the difference between the study of the universe and mere universal study. When they tell us in the very language of theology that all hope and all happiness lies in the knowledge of Nature, that this is a treasure to be valued above rubies and precious stones, how do they limit the word Nature? They mean it certainly to include the whole universe. What is it, then, that they exclude? One would fancy at first sight that they are merely praising knowledge in general, and that they are not particular about kinds of knowledge. Yet we know that they are remarkably exclusive in their notions of knowledge, and that they are as vehement in condemning some sorts as in recommending others. What is there, then, that can possibly be studied besides the universe?

There is something which sets itself up as a just reflection of the universe, and which it is possible to study as if it were the universe itself; that is, the multitude of traditional unscientific opinions about the universe. These opinions are, in one sense, part of the universe; to study them from the historic point of view is to study the universe; but when they are assumed as an accurate reflection of it so as to divert attention from the original, as they are by all the votaries of authority or tradition, then they may be regarded as a spurious universe outside and apart from the real one, and such students of opinion may be said to study and yet not to study the universe.

This spurious universe is almost as great as the genuine one. There are many profoundly learned men whose whole learning relates to it, and has no concern whatever with reality. The simplest peasant who, from living much in the open air, has found for himself, unconsciously, some rules to guide him in divining the weather, knows something about the real universe; but an indefatigable student, who has stored a prodigious memory with what the schoolmen have thought, what the philosophers have thought, what the Fathers have thought, may yet have no real knowledge; he may have been busy only with the reflected universe. Not that the thoughts of dead thinkers stored up in books are not part of the universe as well as wind and rain; not that they may not repay study quite as well; they are deposits of the human mind, and by studying them much may be discovered about the human mind, the ways of its operation, the stages of its development.

Nor yet that the thoughts of the dead may not be of the greatest help to one who is studying the universe; he may get from them suggestions, theories which he may put to the test, and thus convert, in some cases, into real knowledge. But there is a third way in which he may treat them which makes books the very antithesis to reality, and the knowledge of books the knowledge of a spurious universe. This is when he contents himself with storing their contents in his mind, and does not attempt to put them to any test, whether from superstitious reverence or from an excessive pleasure in mere language. He may show wonderful ability in thus assimilating books, wonderful retentiveness, wonderful accuracy, wonderful acuteness; nay, if he clearly understands that he is only dealing with opinions, he may do good service in that department, for opinions need collecting and classifying as much as botanical specimens. But one often sees such collectors mistaking opinions for truths, and depending for their views of the universe entirely upon these opinions, which they accept implicitly without testing them. Such men may be said to study, but not to study the universe.

There are other classes of men of whom much the same may be said. The scientific school, when they recommend the study of Nature, do not mean, for example, the mere collecting of facts, however authentic. Nature with them is not a heap of phenomena, but laws discerned in phenomena, and by a knowledge of Nature they mean a just conception of laws much more than an ample store of information about phenomena. Again, in an age like the present, when methods of inquiry have been laid down and tested by large experience, they do not dignify with the name of the study of Nature any investigation, however earnest or fresh, of the facts of the world, which does not conform to these methods, or show reason for not doing so.

Knowledge of Nature understood in this sense, and obtained in this way, is what we are now told is alone valuable—what human happiness depends on. And assuredly it deserves to be called in the strictest sense theology. If God be the Ruler of the world, as the orthodox theology teaches, the laws of Nature are the laws by which he rules it. If you prefer the pantheistic view, they are the very manifestations of the Divine Nature. In any case the knowledge of Nature, if only it be properly sifted from the corrupting mixture of mere opinion, is the knowledge of God. That there may be another and deeper knowledge of God beyond it does not affect this fact.

But is theology a mere synonym for science? If so, the scientific man may fairly say: "I need not concern myself with it; I have already a name for my pursuit which satisfies me; it does not interest me to hear that there is another name which also is appropriate." Is there no special department of science which may be called theological, to distinguish it from the other departments? It is this which so many scientific men now deny. They say there is certainly such a special

department, but it is not a department of science, for it lies outside the domain of science. It is concerned with causes, whereas science knows nothing of causes; it is concerned with supernatural phenomena which science puts aside as either impossible or unverified. All that this objection means is, that many theologies have been supernaturalistic, and have been occupied with causes, and that though as a matter of course they have not been *exclusively* supernaturalistic and occupied with causes, yet they have been so sufficiently to justify us in appropriating the word theology to systems that have these characteristics. To say, then, that theology is a spurious science, is to say that in most theological systems there is an element more or less predominant which is unscientific. But, even if it were convenient to give to this element the name of theology, it would not follow because theology in this sense may be a spurious science—and etymologically theology is the science of God—that therefore the science of God is a spurious one. You may use the word theology in its etymological sense, or you may give it a more special technical sense to suit convenience; but you must not confound the two senses of the word together. As I have said, all science belongs properly to the science of God, and might legitimately be called theology. I believe also that there is a special department of knowledge which, without necessarily concerning itself with the supernatural, or with final causes, might both legitimately and conveniently be called theology.

Considered in its practical bearings upon human life, the study of Nature resolves itself into the study of two things, a force within the human being, and a necessity without him. Life, in short, is a mechanical problem, in which a power is required to be so advantageously applied as to overcome a weight which is greater than itself. The power is the human will, the weight is Nature, the motive of the struggle between them is certain ideals which man instinctively puts before himself—an ideal of happiness, or an ideal of perfection. By means of science he is enabled to apply the power in the most advantageous manner. Every piece of knowledge he acquires helps him in his undertaking. Every special science which he perfects removes a new set of obstacles, procures him a new set of resources. And in his conflict with natural difficulties his energy and hope are in proportion to his power of knowing and measuring the force he has, and the resistance he will meet with. When he is able to measure this precisely, his hope becomes confidence even in circumstances which might seem the most alarming. We allow ourselves to be hurried through the air at the rate of fifty miles an hour, with a noise and impetus appalling to a by-stander, and all the while read or sleep comfortably. Why? Because the forces we have set in motion are all accurately measured, the obstacles to be met fully known. When the measurement is only approximate, there is not confidence, but only hope predominating over fear. The experienced sailor feels

this; he trusts himself to the open sea, because he knows that he is pretty well matched against the necessity he provokes, though he cannot know that he is the superior because he can calculate a good many of the dangers, though not all.

This is the case in each of the separate undertakings that make up life. To each of them belongs its appropriate knowledge, upon which our equanimity and repose of mind, as far as the particular undertaking is concerned, depend. But life itsef, taken as a whole, is an undertaking. Life itself has its objects which make it interesting to us, which lead us to bear the burden of it. These objects, like those minor ones, are only to be attained by a struggle between the power Will and the weight Nature, and in this struggle also both energy and success depend upon a certain knowledge which may enable us to apply the power with advantage. But the knowledge required in this case is of a more general kind; it is not a knowledge confined to certain sets of phenomena, and giving us a power correspondingly limited, but it is a general knowledge of the relation in which human life stands to the universe, and of the means by which life may be brought into the most satisfactory adaptation to it. Now, by what name shall we call this knowledge?

Every one has his general views of human life, which are more or less distinct. Upon these general views more than upon any thing else connected with the understanding depends the character of every one's life. Morality is theoretically independent of all such views, but practically and in the long-run it varies with them. What has life to give? How far does it lend itself to our ideals? These are practically questions quite as important to morality as those which lie within the province of morality itself—as the questions, what are or what ought to be our ideals? They are also quite as important to human happiness as all particular measures contrived to increase human happiness. No man fights with any heart if he thinks he has Nature against him. If a man believes that men are not made to be happy, he will lose the energy to do even what can be done for their happiness; he will give up the pursuit of virtue if he meets with more than a certain degree of discouragement in it.

Of an unfavorable view of human life there are three principal consequences—crime, languor, and suicide. The majority of crimes, and still more of meannesses, it seems to me, are not committed from bad intentions, but from a despair of human life. "I am sorry, but I *must* do it; I am driven to it; everybody has to do it; we must look at things as they are;" these are the reflections which lead men into breaches of morality. "*Sic vivitur*," says Cicero, selling Tullia. The feeling that life will not allow people to do always what is right, faint perhaps in each individual mind, grows strong when many who share it come together: it grows stronger by being uttered, stronger still by being acted upon; it creates an atmosphere of laxity; morality

retires more and more out of view; until the thought of crime itself, and even of enormous crime, becomes familiar, and at last is carried almost unconsciously into act. It is not, then, from want of morality that men do wrong, but from want of another sort of knowledge. They know what is right and what is wrong; it is not from overlooking this distinction that they fall into the wrong, nor would they escape the danger by reflecting upon it ever so much. What determines their action is a belief in some sort of necessity, some fatality with which it is vain to struggle; it is a general view of human life as unfavorable to ideals.

Another such general view of human life produces apathy. A man who has persuaded himself that we are the creatures of circumstances, or that we are the victims of laws with which it is impossible for us to cope, will give up the battle with Nature and do nothing. Perhaps he has his head full of instances of the best endeavors after happiness failing entirely, or by some fatality producing extreme unhappiness; of the purest and noblest labors producing mischief which complete inactivity would have avoided; how Queen Isabella introduced the Inquisition; how Las Casas initiated the slave-trade; how pauperism has been over and over again fostered by philanthropy; how the Prince of Peace himself, according to his own saying, brought a sword upon the earth. He may think that human life, as it runs on naturally, is not a bad thing, but that all attempts to control it or improve it are hopeless; that all high ideals are merely ambitious; that purpose and, still more, system and all sophistication of life are mischievous. And so he may come to renounce all free-will, he may resign himself to the current of ordinary affairs, and become a mere conventionalist, reconciling himself to whatever he does not like, and gradually induced to tolerate with complete indifference the most enormous evils. Against such a perversion of mind morality is no defense; what is needed is not a new view of what ought to be—such a man knows well enough what ought to be—but a new view of what can or may be, a more encouraging view of the universe.

Sometimes the despair of human life goes to a much greater length. Human life is a game at which we are not forced to play; we may at any time throw up the cards. That only a few do so proves that more or less distinctly most of us have a general view of life not altogether unfavorable. We are for the most part hardly aware of this general view, because it is always the same. We should become painfully aware of it if it were suddenly to change. There is, as it were, a suicide-mark below which our philosophy is always liable to sink. If we came to think life irreconcilably opposed to our ideals, and at the same time were enthusiastically devoted to our ideals, life would become intolerable to us. If our sense of the misery or emptiness of life became for some reason much more keen than it is, life would at last become intolerable to us. With individuals one of these two things is constantly taking place; they might just as well take place with

whole societies or nations. Something of the kind happened with the Stoics of the imperial period. Their philosophy was only just above suicide-mark, and was continually dropping below it. In Asia the same is true of whole populations, with whom the value of life has sunk to the very lowest point.

Of all these classes of men we say very justly that they want faith. Their criminality or languor or despair are the consequences of their having no faith. But we sometimes express the same thing differently and say that they have no God, no theology. With our Christian habit of connecting God with goodness and love, we confuse together the notions of a theology and a faith. Let us reflect that it is quite possible to have a theology without having a faith. We may believe in a God, but a God unfavorable, hostile, or indifferent to us. In the same way we may believe in a God neither altogether friendly nor altogether the reverse. The different pagan theologies were of this kind, and even many Christian sects, while nominally holding the perfect benevolence of God, have practically worshiped a Being who in this respect did not differ from the pagan deities.

It would be legitimate to call such general views of the relation of Nature to our ideals by the name of theology in all cases, and not merely those particular general views which are encouraging. If we believe that Nature helps us in our strivings, we have both a theology and a faith; if we believe that Nature is indifferent to us, or hostile to us, we have no faith, but we have still a theology. We have still a definite notion of God's dealings with us. And this use of the word is not only justified by its etymology; it is much more conformable to actual usage. To identify theology with the doctrine of the supernatural is, as I have pointed out, to narrow the meaning of the word unnaturally, and to appropriate it to a particular part of a particular theological system. The practical effect of giving this technical sense to a word which in the common understanding has a much larger meaning, is to produce a deception. When those who reject the supernatural declare theology to be exploded, they are commonly understood to mean that a vast mass of doctrine, partly moral, partly historical, partly physical, in which the supernatural is mixed up, is exploded, whereas all they really say is that just that part is exploded which is supported only by the evidence of the supernatural. In like manner it is but a small part of what is commonly understood by theology that has to do with final causes, and yet those who consider final causes not objects of knowledge are fond of drawing the inference that all theological systems must be systems of spurious knowledge. Sometimes this juggle which is practised with the word theology becomes grotesquely apparent, and a skeptic will tell us in the same breath that theology deals with matters entirely beyond the range of human intellect, and that theology has been refuted by the discoveries of modern science.

The questions which we all understand to be theological are such as these: Is there a reward for virtue? Is there a compensation for undeserved misery? Is there a sure retribution for crime? Is there hope that the vicious man may become virtuous? Are there means by which the pressure upon the conscience produced by wrong-doing may be removed? Are there means by which the mind disposed to virtue may defend itself from temptation? In one word, is life worth having, and the universe a habitable place for one in whom the sense of duty has been awakened? These questions are answered in different ways by different men. But they are answered in some way by all men, even by those who consider themselves to have no theology at all. Christianity is the system which answers them in the most encouraging way. It says that virtue in the long-run will be happy partly in this life, but much more in a life beyond the grave. It says that misery is partly the punishment of crime, partly the probation of virtue; but in the inexhaustible future which belongs to each individual man there are equivalents and over-payments for all that part of it which is undeserved. It says that virtue, when tried, may count upon help, secret refreshings that come in answer to prayer—friends providentially sent, perhaps guardian angels. It says that souls entangled in wrong-doing may raise themselves out of it by a mystic union with Christ, and burdened consciences be lightened by sharing in the infinite merit of his self-sacrifice. If you ask on what so happy and inspiring a belief rests, the evidence produced is in part supernatural.

This is not only a theology but a faith, the most glorious of all faiths. But those who do not heartily share it, or who consciously reject it, yet give some answer to these questions. They have a theology as much as Christians; they must even have a faith of some sort, otherwise they would renounce human life. It may be stated, perhaps, much as follows:

"We have not much reason to believe in any future state. We are content to look at human life as it lies visibly before us. Surveying it so, we find that it is indeed very different from what we could wish it to be. It is full of failures and miseries. Multitudes die without knowing any thing that can be called happiness, while almost all know too well what is meant by misery. The pains that men endure are frightfully intense, their enjoyments for the most part moderate. They are seldom aware of happiness while it is present, so very delicate a thing is it. When it is past they recognize it, or perhaps fancy it. If we could measure all the happiness there is in the world, we should perhaps be rather pained than gladdened by discovering the amount of it; if we could measure all the misery we should be appalled beyond description. When from happiness we pass to the moral ideal, again we find the world disappointing. It is not a sacred place any more than it is a happy place. Vice and crime very frequently prosper in it. Some of the worst of men are objects of enthu-

siastic admiration and emulation. Some of the best have been hated and persecuted. Much virtue passes away entirely unacknowledged; much flagrant hypocrisy succeeds in its object.

"Still on the whole we find life worth having. The misery of it we find ourselves able to forget, or callously live through. Fortunately we have not imaginations strong enough to realize the sum of it, and we contrive to turn our thoughts away from the subject. And though the happiness is not great, the variety and novelty are. Life is interesting, if not happy. In spite of all the injustice which shocks us in human destiny, the inequality with which fortune is meted out, yet it may be discerned that, at least in the more fortunate societies, justice is the rule and injustice the exception. There are laws by which definite crimes are punished, there is a force of opinion which reaches vaguer offenses, and visits even dispositions to vice with a certain penalty. Virtue is seldom without some reward, however inadequate; if it is not recognized generally or publicly, it finds here and there an admirer, it surrounds itself with a little circle of love; when even this is wanting it often shows a strange power of rewarding itself. On the whole, we are sustained and reconciled to life by a certain feeling of hope, by a belief, resting on real evidence, that things improve and better themselves around us."

This is certainly a very different faith from Christianity. Whether it deserves to be called a faith at all, whether it justifies men in living and in calling others into life, may be doubted. But it is just as much a theology as Christianity. It deals with just the same questions and gives an answer to them, though a different answer. Both views, whatever may be professed, are views about God. Christianity regards God as a friend; it says that he is Love. The other view regards him as awful, distant, inhuman, yet not radically hostile.

It is said that such vague, general views do not deserve to be called science. This is of course admitted. There exists at the present moment no scientific theology independent of the supernatural and of the search for final causes. But this is not because no such theology can be constructed, but merely because it has not yet been constructed. Evidently it is constructing itself fast. The more men come to know Nature and to feel confidence in their knowledge, the more eagerly they will consider what is the attitude of Nature toward human beings. This question is not one which is in any way removed from human knowledge, it is not one which it can be considered morbid to betray curiosity about. Yet this is *the* question of theology. Not only is it the only question with which theology ought to be concerned; it is the only question with which theology ever has been concerned. The theologies of the world are merely different attempts to answer it. If they have for the most part trespassed upon the domain of the supernatural, this has not been because theology is necessarily concerned with the supernatural, but in some cases because the line

between the natural and supernatural had not been clearly drawn, in some cases because it was honestly believed that supernatural occurrences had happened and could be substantiated by sufficient evidence, and that such occurrences were calculated to throw new light upon the relation of God to man. If this belief was a delusion, theology must fall back upon the evidence of Nature. She may have to alter her idea of God, she may have to regard him with fear and cold awe as in the days before the Gospel was published; she may cease to be a faith, and may become instead an oppression—a scientific superstition. But theology will remain notwithstanding a perfectly legitimate science, one which, whether under that name or under another, men will always study with an interest they can feel in no other, one which stands in a more intimate relation than any other to morality, and must always be taught in conjunction with morality.

We lay it down, then, that the subject of theology is the relation assumed by the universe toward human ideals, and, as we propose here to waive the question of the supernatural and to treat the universe as consisting solely of the order of Nature, this will be the same thing for our present purpose as the relation assumed by Nature toward human ideals. But here we must beware of a common misconception. It is often said that when you substitute Nature for God you take a thing heartless and pitiless instead of love and goodness. Undoubtedly the God in whom Christians believe has much more of love and goodness than can be discovered in Nature. But when it is said that there are no such qualities in Nature, that Nature consists of relentless and ruthless laws, that Nature knows nothing of forgiveness, and inexorably exacts the utmost penalty for every transgression, a confusion is made between two different meanings which may be given to the word Nature. We are concerned here with Nature as opposed to that which is above Nature, not with Nature as opposed to man. We use it as a name comprehending all the uniform laws of the universe as known in our experience, and excluding such laws as are inferred from experiences so exceptional and isolated as to be difficult of verification. In this sense Nature is not heartless or unrelenting; to say so would be equivalent to saying that pity and forgiveness are in all cases supernatural. It may be true that the law of gravitation is quite pitiless, that it will destroy the most innocent and amiable person with as little hesitation as the wrong-doer. But there are other laws which are not pitiless. There are laws under which human beings form themselves into communities, and set up law courts in which the claims of individuals are weighed with the nicest skill. There are laws under which churches and philanthropical societies are formed, by which misery is sought out and relieved, and every evil that can be discovered in the world is redressed. Nature in the sense in which we are now using the word, includes human nature, and therefore, so far from being pitiless, includes all the pity that belongs to the whole

human family, and all the pity that they have accumulated, and, as it were, capitalized in institutions, political, social, and ecclesiastical, through countless generations.

People are misled by the fact that Nature is often used in another sense, and opposed, not to the supernatural, but to man. Nature is, for shortness, often put instead of inanimate Nature. Inanimate Nature is of course pitiless. It consists of laws which, like the law of gravitation, take no note of happiness or misery, virtue or vice. But if we abandoned our belief in the supernatural, it would not be only Nature in this restricted sense that would be left to us; we should not give ourselves over, as it is often rhetorically described, to the mercy of merciless powers—winds and waves, earthquakes, volcanoes, and fire. The God we should believe in would not be a passionless, utterly inhuman power. He would indeed be a God, often neglecting us in our need, a God often deaf to prayers. Nature including humanity would be our God. We should read his character not merely in the earthquake and fire, but also in the still small voice; not merely in the destroying powers of the world, but, as Mohammed said, in the compassion that we feel for one another; not merely in the storm that threatens the sailor with death, but in the life-boat and the Grace Darling that put out from shore to the rescue; not merely in the intricate laws that confound our prudence, but in the science that penetrates them and the art which makes them subservient to our purposes; not merely in the social evils that fill our towns with misery and cover our frontiers with war, but in the St. Francis that makes himself the brother of the miserable, and in the Fox and Penn that proclaim principles of peace.

Let us take one of the principal maxims of the supernatural theology, and observe how it is modified by the rejection of the supernatural. That the just man will assuredly be rewarded with happiness is a maxim resting upon evidence involving the supernatural. It depends upon belief in a God of much more goodness and justice than we can find in Nature; it assumes a future state of which science furnishes no clear evidence. Even when the Psalmist, speaking merely of the present life, wrote, "I have been young, and now am old, and yet saw I never the righteous forsaken, nor his seed begging their bread," he perhaps thought of supernatural interpositions by which evil was averted from the just man. Suppose, now, that we repudiate all such beliefs, and confine ourselves strictly to the facts of Nature as we discover them from uniform experience. Let us suppose that the ordinary laws of Nature govern the lot of the just man, and that no exemptions are made in his favor. Do we find that these ordinary laws take no account of his justice, and that his prospects are in no respect different from those of the unjust man? Is Nature, as distinguished from the supernatural, regardless of the distinction between virtue and vice? No doubt Nature is not a perfectly just judge. The just

man has misfortunes like the unjust; he may suffer from accident or disease. His justice may be denied; he may suffer the penalties of injustice. All this may happen in particular cases, and yet no one doubts that on the whole the just man reaps a reward for his justice. A very simple law operates to reward him. By his justice he benefits the community, and the community, partly out of gratitude, partly out of an interested calculation, repay him for the service he has done. This law fails of its effect in a good number of cases, but in the majority of cases it does not fail. And when it fails, it seldom fails altogether. There is generally some reward for justice, if not always an adequate reward. Accordingly, not only Christians, or those who believe in something more than Nature, but those whose only God is Nature, and even those whose knowledge of Nature is very superficial, fully recognize that virtue is rewarded. "Honesty is the best policy" has become a proverb, and hypocrites have come into existence hoping to secure the reward without deserving it. We see, then, that those who believe in Nature only may be said to believe not only in a God, but, in some sense, in a personal God. Their God, at least, has so much of personality that he takes account of the distinction of virtue and vice, that he punishes crime, and that he relieves distress.—*Macmillan's Magazine.*

## THE GREAT IOWA METEOR.

By Dr. GUSTAVUS HINRICHS.

ON the evening of Friday, February 12, 1875, at twenty minutes past ten o'clock, one of the most brilliant meteors, of modern times illuminated the entire State of Iowa, and adjacent parts of the States of Missouri, Illinois, Wisconsin, and Minnesota. The southeastern portion of Iowa was bright as day, while the great meteor, in descending to the earth, passed from Appanoose County to Iowa County. The meteor, in rapidly moving through the atmosphere, produced a great variety of sounds—rolling, rumbling, and detonations of fearful intensity—which in a large portion of Iowa County shook the houses as if moved by an earthquake.

But three days after the great phenomenon, a meteoric stone, weighing seven pounds, was found by Miss Sarah Sherlock, while on her way from school—precisely where observers had seen a "glowing coal" descend to the earth. In April and May, while the farmers were cultivating the land, about 400 pounds of meteoric stones were gathered on the meteorite-field of Iowa County. Quite recently two large meteorites have been found, aggregating 120 pounds. But these 500 pounds of meteoric stones apparently are only a portion of a smaller fragment of the entire meteoric body, so that the whole mass

falling to the earth, as the great Iowa meteor of February 12, 1875, must have weighed about 5,000 pounds.

Even what has been gathered thus far permits us to rank this meteor among the best observed and richest in meteorites on record. Such are the meteors of Pultusk, Poland (January 30, 1868); Knyahinya, Hungary (June 9, 1866); Orgueil, France (May 14, 1864); Guernsey County, Ohio (May 1, 1860); Parnallee, India (February 28, 1857); and L'Aigle, France (April 26, 1803).

Thinking that so remarkable a meteor and so rich a shower of meteorites deserve the attention of the readers of THE POPULAR SCIENCE MONTHLY, we offer a short description of them, and shall close with a few suggestions in regard to the origin of these bodies, and their place in the grand history of cosmos.

I. THE GREAT IOWA METEOR.[1]—The great Iowa meteor consisted of an elongated, pear-shaped mass of the most dazzling whiteness. The bulk of this mass was about 2,000 feet long and 400 feet in diameter; the narrow white trail was about 4,000 feet long and 40 feet in diameter. This body was posteriorly enveloped by a much less brilliant trail, shading from orange inside to greenish outside, and extending about nine miles along the described path of the meteor. Persons in the track of the meteor saw a brilliant circular disk of white light, surrounded by an orange to greenish halo, the dim light of which was constantly traversed by narrow bands of brilliant white, running from the central disk in irregularly-curved lines toward the circumference. As this body, increasing in brilliancy and apparent magnitude, was rapidly approaching, both men and animals were overcome with fear.

The meteor, when by striking the atmosphere of the earth it became visible, was at an altitude of 150 miles vertically above the little village of Pleasantville, about midway between Kirksville and Milan, in Northern Missouri. Descending at an angle of about 45° toward the earth's surface, it moved a little east of north, gradually deviating more and more toward the east, so as to describe a curve,[2] the concavity of which is turned eastward. This track of the meteor passed a couple of miles east of Centreville and Moravia in Appanoose County, Iowa; almost directly over Eddyville on the Des Moines River; crossed almost diagonally the northeastern (Prairie) township of Keokuk County; passed one and a half mile east of Marengo in Iowa County, and finally exploded over a point three miles southwest of the little station of Norway on the Chicago & Northwestern Railway, over the boundary-line of Benton and Iowa Counties, at an altitude of about ten miles.

[1] The facts in regard to the meteor we have collected from the very full and reliable "Account of the Detonating Meteor of February 12, 1875. By C. W. Irish, C. E., Iowa City, Iowa, *Daily Press* Job-Printing Office, 1875."

[2] The total length of the orbit is 210 miles; the time during which the meteor described this orbit was about ten seconds: hence the velocity was about 21 miles a second.

While the meteor crossed the northwestern (Prairie) township of Keokuk County, it was seen to divide into two unequal parts, a small eastern portion continuing its motion northeastward, but soon losing its brilliancy, and a seven to fourteen times greater western portion which remained intensely brilliant until its final explosion. *It was the smaller portion of the meteor which produced the meteorite shower in Iowa and Amana Townships of Iowa County;* hence it is highly probable that several thousand pounds of meteorite, some in pieces of over a hundred pounds, will yet be found east and north of the final explosion of the main portion of the meteor, that is, in Florence Township of Benton County, in Fairfax Township of Linn County, and in Lenox Township of Iowa County. In fact, observers have seen "large glowing coals," as they call them, fall in this region where Linn, Benton, and Iowa Counties meet.

While dividing, the meteor produced two tremendous detonations, and, after the main body had crossed the railroad at Marengo, it produced three terrific detonations, which shook the buildings for miles around, so as to create in the residents the fear of an earthquake.

Besides these detonations, the meteor was accompanied with a variety of other sounds, heard over a circular area of 150 miles in diameter. To those farthest away from the orbit it sounded as if their chimney was on fire, and an astonishingly large number of persons missed the sight of the meteor because they hurried to their stoves and flues to check the apparent fire. Those nearer the track heard a prolonged rumbling and rolling sound, which they compare to that produced by the running of a train over a high and long trestle-bridge. Others, still nearer the region of final explosion, hurried up-stairs, thinking that the plastering had fallen on the heads of their children sleeping in the upper story. Many in this same region heard the clank and clatter of heavy, hard bodies striking against each other, or against the hard ground.

II. The Iowa County Meteorites.—The meteorites thus far found occur in an elliptical area stretching from Amana vor der Höhe, in Amana Township, to Boltonville, in Iowa Township, a distance of eight miles. The minor axis of this ellipse measures about three miles. The entire meteorite-field of Iowa County thus far covers, therefore, an area of eighteen square miles. In the northwest the largest pieces are found; toward the southeast, the meteorites become gradually smaller. This agrees with their derivation from the minor portion of the meteor. As the entire drift was eastward, the resistance of the air would, to some extent, produce precisely this distribution of the meteorites according to size.

The principal village near the meteorite region is Homestead,[1] a

[1] I gratefully acknowledge many personal obligations to residents of this place, especially to Messrs. William Moerschel, Frederick Moerschel, Geisler, Fehr, Dickel, Noë, and others.

station on the Chicago, Rock Island & Pacific Railroad, about twenty miles west of Iowa City. This little station became the headquarters

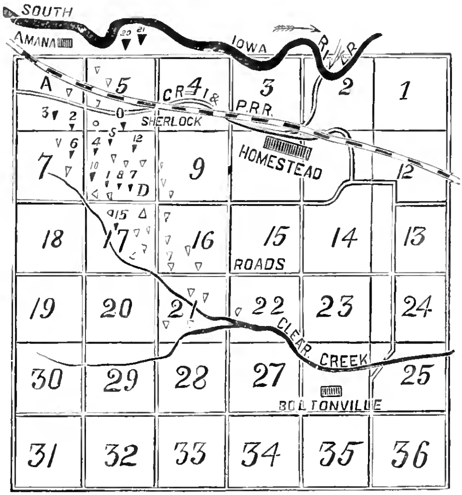



Fig. 1.—Iowa Township, Iowa County, Iowa.

of the "meteor-brokers;" for two dollars a pound had been offered for all these stones. Enormous profits[1] were made, creating a "meteor excitement" in the region.

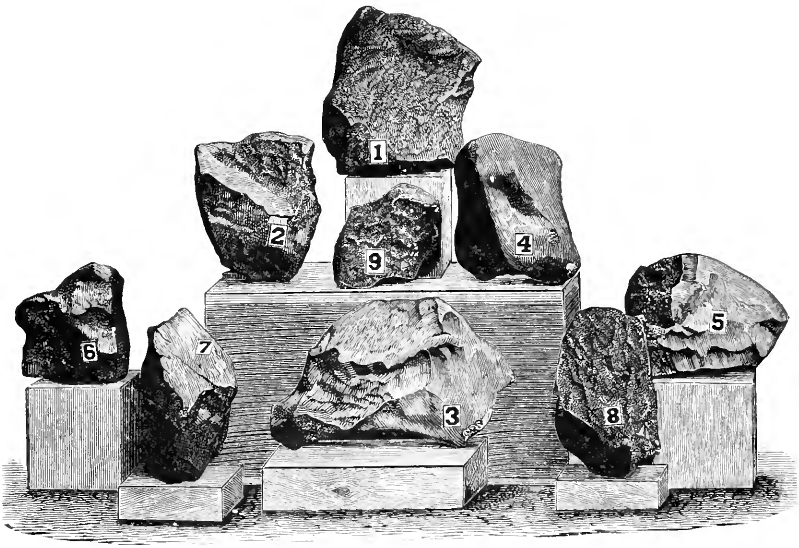



Fig. 2.—Iowa County Meteorites.

[1] One lot of stones, weighing 44 pounds, was found by Mr. Espenlaub on his land at *A*, section six, Iowa Township. The above-mentioned agent bought this of Mr. Espenlaub for $2.50, and sold it to an astronomer for $88, thus making a profit of $85.50 on an outlay of $2.50.

Mineralogy pertaining to my chair of physical science in the Iowa State University, I felt it my duty to furnish the mineralogical cabinets with good specimens of the meteorites which fell in my neighborhood. I have, through the personal and financial assistance of the Hon. John P. Irish, of Iowa City, brought together three collections, the first two of which have been photographed. The subjoined cut is a copy of the photograph of the first collection. It shows the general form of each of the specimens, numbered in the order of their weight. The photographs themselves, in one-fifth natural size, are very excellent, permitting even a close study of the granulations and surface. The above cut gives the specimens in one-seventh of their natural size.

The following catalogue gives the specimens of my collections in the order of their weight. The numbers correspond with those on the map of Iowa Township. No. 0 on the map indicates the "Sherlock Stone," the first one found:

| Collection I. | II. | III. | Weight, Lbs. | Oz. | Weight in Grammes. | Presented to the Mineralogical Museum of |
|---|---|---|---|---|---|---|
| .. | .. | 21 | 21 | 00 | 9,500 | .................... |
| .. | .. | 20 | 12 | 4 | 5,761 | .................... |
| 1 | .. | .. | 10 | 4 | 4,650 | Paris. |
| 2 | .. | .. | 8 | 5 | 3,793 | London. |
| 3 | .. | .. | 8 | 0 | 3,620 | .................... |
| .. | 10 | .. | 7 | 13 | 3,562 | .................... |
| .. | 11 | .. | 7 | 3 | 3,268 | St. Petersburg. |
| .. | 12 | .. | 6 | 10 | 3,013 | .................... |
| 4 | .. | .. | 6 | 5 | 2 856 | Vienna. |
| .. | 13 | .. | 5 | 14 | 2,663 | Brussels. |
| 5 | .. | .. | 5 | 3 | 2,634 | Copenhagen. |
| .. | 14 | .. | 5 | 7 | 2,464 | Haarlem. |
| 6 | .. | .. | 5 | 0 | 2,274 | Berlin. |
| .. | 15 | .. | 4 | 11 | 2,142 | Paris. |
| 7 | .. | .. | 4 | 8 | 2,040 | Christiania. |
| 8 | .. | .. | 4 | 0 | 1,819 | Stockholm. |
| .. | 16 | .. | 3 | 6 | 1,545 | Munich. |
| 9 | .. | .. | 2 | 3 | 997 | Lausanne. |
| .. | 17 | .. | 1 | 7 | 669 | .................... |
| .. | 18 | .. | 1 | 4 | 567 | .................... |
| .. | 19 | .. | 1 | 4 | 560 | West Point, New York. |
| Total........ | | | 133 | 00 | 60,500 | |

But a few days ago (on June 30th) I received a dispatch from the meteorite headquarters that quite a large specimen had been found. Since, an additional, somewhat smaller stone has been found on the same section of land, namely, on section thirty of the township, directly north of Iowa Township—or about two miles north of the spot *A* in section six of the map, but a little south of the society village called Amana vor der Höhe. I have visited this place, and been kindly permitted to examine these truly beautiful specimens. The larger meteorite forms an irregular, rounded rhomb, 15 inches diagonal and 8

inches thick; it weighs 75 pounds, or 33.6 kilogrammes, and is completely covered with a black crust, i. e., a complete stone. The smaller meteorite forms an irregular rhomboid, the diagonals of which are 16 and 10 inches, while it is 12 inches thick; it weighs $48\frac{1}{2}$ pounds, or 21.1 kilogrammes. One of its sides has but a secondary crust, so that another piece of perhaps 20 pounds must be found in the neighborhood. The smallest complete stone is in the possession of Mr. William Moerschel; it is a lenticular stone, weighing two ounces only. The largest stone found weighs, therefore, 624 times as much as the smallest!

The two admirable specimens just described belong to the largest meteoric *stones*[1] on record, as may be seen from the following table, which, however, is probably not quite complete below forty kilogrammes.

| METEORITE OF | In Museum at | Weight. | |
|---|---|---|---|
| | | Lbs. | Kilogrammes. |
| Knyahinya, 1866........ | Vienna.................. | 614 | 279 |
| Murcia (?)............. | Madrid (?)............... | 251 | 114 |
| Parnallee, 1857.... ..... | London................... | 147 | 67 |
| Guernsey County, 1860... | Marietta, O............... | 103 | 46.7 |
| Juvinas, 1821........... | Paris.................... | 92 | 42 |
| Iowa County, 1875....... | Amana Society............ | 74 | 33.6 |
| Iowa County, 1875....... | Amana Society............ | 48.5 | 21.1 |
| Ohaba, 1857............ | Vienna. ............... | 35 | 16.0 |
| Vouillé, 1831........... | Paris.................... | 33 | 15 |
| Mezö-Madaras, 1852..... | Vienna.. ................ | 22 | 9.9 |
| Iowa County, 1875... ... | No. 21, Hinrichs's collection. | 21 | 9.5 |

The Amana Society has confided these two remarkable specimens to me for study. They appear to have formed but one stone when the meteor first struck our atmosphere.

The number of meteorites thus far found in Iowa County is about one hundred; the total weight is over 500 lbs., or 225 kilogrammes.

The *Iowa County meteorites* are all alike, bounded by irregular plane surfaces, indicating the usual fragmentary nature of meteorites. They are all covered with a black crust, formed during the cosmical part of their motion through the earth's atmosphere. This crust is not due to fusion, but simply to the heating of the outer layer of the stone to a red heat, as has been proved by Meunier. Indeed, the gray mass of these meteorites turns very readily black by exposure to a red heat. The surface of these meteorites shows all the ordinary impressions of meteoric stones; the finger-marks, granulations, ripples simulating the flow of fused matter, etc. The anterior side is, as commonly, deeper black than the posterior side; the latter has the smaller finger-marks.

[1] Of meteoric *irons* many of much greater weight are found in museums. The largest of all is the *Cranbourne* iron, Australia, of 4,000 kilogrammes, at the British Museum. Next in weight is the *Charcas* iron, weighing 780 kilogrammes, at the Museum of the Jardin des Plantes in Paris. The largest iron in the K. K. Hof-Mineralienkabinet at Vienna is from *Elbogen*, Bohemia, and weighs 78 kilogrammes.

These meteorites are exceedingly tough, so that it is difficult to break them up; this is due to the iron grains being partly connected by fibres and folia. Still, the nickeliferous iron is present in detached masses, or occurs sporadically in the stone. Hence these meteorites belong to the great class of *Sporadosidères* of Daubrée. In this class Daubrée distinguishes three species: those containing much, little, or but very little iron, so that it can only be recognized by a magnifier or a microscope; these species he designates as Poly-, Oligo-, and Krypto-Sporadosidères. Accordingly, the Iowa County meteorites are *Oligo-Sporadosidères*, that is, meteoric stones containing but little plainly visible metallic iron, in detached grains. I find that these stones contain seven per cent., by weight, of metallic iron. The specific gravity of these meteorites is, therefore, rather low, namely 3.57.

The fracture is very rough and uneven, showing the lustrous metallic iron, and also irregularly rounded spots of lighter gray to white on the dark-gray ground. These rounded stony concretions show very well on a ground surface of the stone; they have given rise to the name *Chondrites*, introduced by G. Rose, for this class of meteorites. I find that the grains of lighter color contain less of iron silicate, but otherwise are composed of the same minerals.

These minerals are essentially two, namely, *Olivine*, which is soluble in muriatic acid, and *Pyroxene*, which is not soluble in this acid.

Besides, the stone contains some troilite, that is, iron sulphide. The following table gives the mineralogical composition of the Iowa County meteorites, according to a number of analyses:

| | | | | |
|---|---|---|---|---|
| *Non-Magnetic* | Troilite | 1.8 | Soluble | 54.7 |
| | Olivine | 52.9 | | |
| | Pyroxene | 44.9 | Insoluble | 44.9 |
| *Magnetic* | Nickeliferous Iron | 7.5 | | |

The olivine is the variety known as *Hyalosiderite*, which contains two atoms of magnesium to each atom of iron. In the pyroxene of these meteorites the same ratio of iron and magnesium obtains; hence this variety is *Hypersthene*.

The following table gives the result of my analyses of the average composition of the Iowa County meteorites:

| METEORITES. | Iron. | Nickel. | Sulphur. | Ferrous Oxide. | Magnesia. | Lime. | Silica. | Sum. |
|---|---|---|---|---|---|---|---|---|
| NON-MAGNETIC: | | | | | | | | |
| Troilite | 1.1 | ...... | 0.7 | (1.5) | ...... | ...... | ...... | 1.8 |
| Hyalosiderite | ...... | ...... | ...... | 15.2 | 17.5 | 0.6 | 19.6 | 52.9 |
| Hypersthene | ...... | ...... | ...... | 8.8 | 9.7 | 2.2 | 24.2 | 44.9 |
| Loss, traces | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 0.4 |
| Sum | 1.1 | ...... | 0.7 | 24.0 | 27.2 | 2.8 | 43.8 | 100.0 |
| MAGNETIC: | | | | | | | | |
| Nickeliferous Iron | 6.6 | 0.9 | ...... | ...... | ...... | ...... | ...... | 7.5 |
| Total | 7.7 | 0.9 | 0.7 | 24.0 | 27.2 | 2.8 | 43.8 | 107.5 |

A trace of manganese remains with the ferrous oxide—also a small amount of alumina. The trace of sodium is sufficient to give a brilliant line in the spectroscope; the lithium-line, while quite distinct, is not brilliant.

An extended report of my examination of the Iowa County meteorite will be published, as soon as the more careful investigation of the concretions shall have been completed, which examination is delayed for want of material. I am unwilling to sacrifice any of the fine specimens above enumerated for this purpose.

III. The Origin of Meteorites.—The researches of Daubrée and Meunier, of Paris, have demonstrated that meteorites are fragments of one or more planetary bodies, which, by some great convulsion, has been broken to pieces. Furthermore, we possess abundant evidence that the earth, in its structure, corresponds, at different depths, to the different varieties of meteorites: from those without iron (Asydères), through the Oligosidères to those consisting exclusively of nickeliferous iron (Syssydères). Hence if our earth, through the action of some cause, should be broken to pieces, these pieces would be meteorites and describe orbits around the sun similar to and near by the orbit of the earth.

But the cosmical spaces are filled with a very rare, slightly-resistant medium. Hence, the fragments being different in density and in dimensions, would be differently affected by this resisting medium. The smaller fragments and those of less density would lose their velocity of revolution around the sun more rapidly than those of greater size and higher density. In other words, all fragments would, while revolving around the sun, also descend toward the same, but at different rates: the smaller and lighter fragments would sink faster than the larger and heavier.

These terrestrial meteorites would, therefore, gradually reach the orbits of the inner planets. On Venus first would appear meteorites composed of the rocks of our earth's superficial crust, limestone, shales, quartz, granite, serpentine, etc. These would be associated with small meteorites of more dense materials derived from the deeper portions of the earth. At a later period, Venus would receive terrestrial meteorites from deeper portions of our earth, corresponding to Oligosidères. These would also be associated with small meteorites of denser materials, thus foreshadowing the third meteorite era, in which the dense masses of the interior metallic core of our earth would have sunk far enough toward the sun to reach the orbit of Venus. The mechanical problem herein involved I pretty completely solved about ten years ago.[1]

Now, it is furthermore well understood that it will be a long time

[1] "On the Density, Rotation, and Relative Age of the Planets," *American Journal of Sciences*, 1864, vol. xxxvii. "Introduction to the Mathematical Principles of the Nebular Theory, or Planetology," *American Journal of Sciences*, 1865, vol. xxxix.

before the earth is so broken up; for celestial bodies pass through their cosmical cycles in times somewhat proportional to their magnitude. Therefore, long before the earth meets this, her final doom, the moon will have been so broken up that her "lunar meteorites" will have been placed in the mineralogical museums, I trust, at less than "two dollars a pound."

Accordingly, we must look for the origin of our meteorites up away from the sun. We believe that they are fragments of some of the more minute asteroids of which hundreds yet continue to move between Mars and Jupiter. The frequent stony meteorites now falling, therefore, probably are the forerunners of a period of frequent iron meteorites, corresponding to the deeper portions of the same minute planet, the exterior layers of which have been reaching us quite frequently of late. The meteoric irons of our cabinets must have belonged to another asteroid, broken up at an earlier date than the asteroid now yielding the large and frequent crops of meteoric stones.

This is not the place for a more complete development of this view. But, as every reader inevitably would ask the question, "Whence these meteorites?" we deemed it best to give our answer.

The nebular theory fully accounts for the planetary system in its glory; but this harmony is finally followed by a breaking up and destruction of each body, which then as meteorites continue to move, truly cosmical fossils, until they find a temporary rest on the orbs which are nearer the grand centre of our world, the glorious sun.

## HOUSE-VENTILATION.

"OLD FULLER"—wise, witty, and thoroughly practical—pronounced by Coleridge to be "incomparably the most sensible, the least prejudiced great man of an age that boasted a galaxy of great men"—tells us that "houses ought to be built to live in, and not to look at;" and it seems strange that a truth so obvious should require to be enunciated by an authority so great.

Since Fuller's time we have in all respects vastly progressed. We are eminently a practical people, and are undisturbed in our utilitarian pursuits by purely æsthetic proclivities. But, if we have not realized the beautiful in architecture, we ought at least to have advanced toward the attainment of utility. Unfortunately, however, the aim and development of our national characteristics have not taken the useful direction of making our houses "fit to live in"—but only to let, and to sell!

To live in a house in the Fullerian sense means, of course, existence therein under the best attainable conditions of health, ease, com-

fort, and economy. In other words, such desiderata mean proper shelter with *efficient ventilation and adequate warming.* And these now, as in the seventeenth century, are still indeterminate conditions in the problem of house-building.

If houses in Fuller's time were not built to live in, at least they were pleasant to look at. They pleased the judgment even more than the eye, for they fairly grew out of the requirements of the age, and were, in a great measure, the natural result of the ordinary materials at command. Not so the houses of the present day. Other times can boast their own styles. The castellated, the ecclesiastical, the Elizabethan, all express some idea, and are types of their own several ages and wants. But the nineteenth century, with its unlimited resources of iron and glass and its own peculiar civilization, has no distinctive style. The highest reach of architectural effort is a slavish reproduction of forms from which the spirit has lapsed with time and changed with custom. The interest attaching to a building of former ages arises partly from association and partly from the picturesque effect which age throws over it with its decay and damp. We might also say something of the poetic charm of desolation, the interest of rarity and historic truth—all, in short, which we instinctively feel can never be produced by the most perfect imitation.

But all that imagination and feeling conjure up, wherewith to clothe the rude forms of the past, are evidences of disuse and a superseded civilization. They no more accord with the full life and energy of the present age than hand-spinning does with the results of the steam-engine; and low wainscoted rooms, narrow windows, grotesque ornamentations, and rude domestic appliances, are only endurable when seen through the light of a tender, loving, hereditary pride. When, therefore, we see the constant and deliberate reproduction of old forms, and on assumed æsthetical grounds, we are justified in saying that such choice betokens the surrender of the judgment to a perverted taste; that the beauty of utility is not understood; and that the true object of house-building has yet to be learned.

The anomaly is made more apparent, if the result is less uncomfortable and unhealthy, when an architect breaks away from wholesome copying, and steals a little from various styles for the outside "treatment" of a modern dwelling. The result is a nondescript medley. Simplicity is ignored, proportion defied, fitness unthought of. For a rich man's use expense is disregarded in profuse variety; and for a poor man's dwelling—the balance is restored through the saving made in "jerry-building;" the result being what we have already stated, that average houses in the present day are built neither to live in nor to look at, but to let or to sell.

The anomaly of a medley of over-ornamentation and mixed styles in the individual villa, erected in the outskirts of large towns, is intensified into absolute mischief when such medley is applied to public

buildings and street architecture. In the former it is bad taste; in the latter it is bad taste *plus* the evils that spring from a foul atmosphere. Profuse embellishment, in a large town, is only another name for traps to catch soot.

Passing from the perverted taste shown on the exterior, we must notice the unscientific arrangements in the interior of our average domestic dwelling.

Pure air is as absolute a necessity to human beings as good food and untainted water. Bad air kills, however, by inches only, while innutritious food and foul water do their evil work with quick precision—both, in the end, leading to the same results—impaired vitality, disease, and a high rate of mortality. Nature undoubtedly has a great power of adaptation; but, under a prolonged state of unfavorable sanitary conditions, that capacity is harshly exercised. Every abnormal condition of physical existence, arising from bad air, insufficient food, or undue exposure, and producing no immediate results, necessitates the drawing of sanitary bills on futurity to be paid with heavy interest; and the very poor, from necessity, and the rich, from ignorance and apathy, spend shortened lives of prodigal thoughtlessness, ending in vital bankruptcy. Hence the crowded inhabitants of the back slums of large towns live, unconsciously, their life of lowered health, under conditions which would kill off the fox-hunting squire in a month. This depressed level of vitality and deferred penalty furnish one explanation of the general indifference to pure air.

Another cause may be found in its omnipresence and the continuity of its use. Providence has bestowed on mankind a limitless amount of pure air. It surrounds us, it is always ready without effort; its chemical composition never varies, and it costs no money. If the supply were less ample, or it could only be obtained by an outlay of money or labor, or its use were intermittent, we, no doubt, should value it at its intrinsic worth, be more jealous of its misuse, and study more closely its influence upon health.

The nineteenth-century house, however, has no special provision for the admission of fresh air, and, except in warm weather, its entrance is jealously prevented. Ventilation is change of air, and, unless scientifically arranged, and especially warmed in cold weather, such change of atmosphere means cold currents, with their attendant train of colds, catarrhs, bronchitis, neuralgia, rheumatism, and the evils that spring from them. Again, perfect ventilation means the realization, in a great measure, of the condition of air out-of-doors; and few persons, probably, have estimated the enormous flow of air requisite to effect this. The ordinary notion is, that the proper renewal of the air in a room ought to be measured by the quantity passed through the lungs of an individual in any given time. But an ounce of poison may vitiate a gallon of water; and nothing short of the removal and renovation *of the whole of the tainted portion*, as fast

as it becomes tainted, can insure perfect salubrity. Dr. Dalton estimated the average respiration of a man to be 24 cubic inches, and the average number per minute to be 20: consequently, 400 cubic feet pass through the lungs of an ordinary man in twenty-four hours; while the fallacy to which we have alluded assumes that a supply of 400 cubic feet in the room, in twenty-four hours, insures sufficient ventilation. Certainly, if any one would draw breath out of one bag, and discharge the tainted air from his lungs into another, he would always breathe good air. But it is calculated that a man will taint and render unwholesome by mixture 17,500 cubic feet of air in the twenty-four hours; for every respiration not only robs the imbibed 24 cubic inches of a certain portion of its oxygen, but it has mixed with it a quantity of carbonic-acid gas and some vapor; and theoretically, at least, the second respiration, drawn from a room in which the air is stagnant, begins the process of blood-poisoning.

The first rule, therefore, to be laid down in reference to perfect ventilation, prescribes the entire removal of the whole *stratum* of air tainted in a room by each respiration; for by no less a movement do we conceive it possible to take away the polluted air. This removal must be effected no less than twenty times per minute. Part of the expired air being rarefied by the heat of the lungs will rise, and part—the carbonic-acid gas—will fall. Twenty-four cubic inches, thus spread, may be assumed to taint a stratum, at or about a mouth of an occupant, of 18 inches. Any lateral movement would, in the case of several occupants, simply sweep the air breathed by one person close by the lips of some other; and hence we hold, as a corollary to this rule, that the prescribed movement should be either up or down, not lateral.

But the preceding calculation is based upon the minimum consumption of each person during quiescence. When talking, laughing, singing, walking, or dancing, the average respirations are, relatively, quickened, the consumption of air increased, and the necessity for a rapid change of atmosphere further enhanced. The amount of air inspired has been found to be as follows:

| | |
|---|---|
| When lying down (say) | 1.00 |
| " sitting | 1.18 |
| " standing | 1.33 |
| " singing | 1.26 |
| " walking 1 mile per hour | 1.90 |
| " " 2 miles " | 2.76 |
| " " 3 " " | 3.22 |
| " " 3 " " and carrying 34 pounds | 3.50 |
| " " 4 miles per hour | 5.00 |
| " " 6 " " | 7.00 |
| " riding (trotting) | 4.05 |
| " swimming | 4.33 |

The above-ascertained accelerations of the respiratory organs sufficiently indicate the effect produced by all kinds of in-door exertion,

and incontestably prove, from increased demand, the necessity for increased supply.

This view, which we admit to be an extreme one, of ventilation requirements in dwelling-houses, may serve, at least, to impress upon many the advantage of living as much as possible out-of-doors, and of taking some regular exercise. On the other hand, it will certainly show the futility of the petty, peddling expedients adopted under the name of ventilation, when the prevailing apathy is stirred to such an extent as to cause "something to be done," which may be a little better than resting content with doing nothing at all.

What we have said of the indifference, ignorance, or error as to ventilation, has had special reference to the designers of houses "built to look at," and to sell; but a deficiency so general and complete cannot be ascribed to those only who, while they occupy the position of teachers, are compelled to take their cue from the taught. The education of public opinion is a delicate process. It is essentially one of action and reaction, requiring concurrence to initiate and coöperation successfully to work out. The illness of the Prince of Wales did much to amend house-drainage, for the torpidity of public opinion gets well aroused when royalty suffers; and the asphyxiation of a nobleman or the blood-poisoning of a bishop would, no doubt, be a wonderful stimulus to the application of common-sense to house-ventilation.

The second rule that we lay down relates to the conditions of the supply of the large volume of fresh air we have indicated as necessary for perfect health: it must be tempered—warmed. No raw, damp, frosty air of an ever-changing temperature ought to have uncontrolled and constant ingress to our dwelling. Air out-of-doors is suited to out-of-door habits. It is healthy and bracing when the body is coated and wrapped, and prepared to meet it, and when excercise can be taken to keep up the circulation; but to live under cover is to live artificially, and all essential conditions must be dealt with to suit an abnormal state, and all the evils attaching to ventilation, as generally effected, spring from the neglect of this consistency. We admit raw air, and we warm it most at the critical moment when we send it up the chimney! We freeze our backs and scorch our faces. We sit with our feet in a current of cold air, and our heads are kept in an impure atmosphere, vitiated by human lungs, the products of gas-consumption, and loaded with animal matter. We have a torrid zone bordered by the hearth-rug, and the arctic regions in the neighborhood of the windows and door. Medical men shiver at the abstract idea of violent changes of temperature, but they raise no warning voice against delicate patients being subjected to a variation of 60° in a modern drawing-room. The notion is stereotyped that night air is unwholesome. The casual admission of air during the day is no longer permitted, all known apertures are carefully closed, and, if intention

could be realized, not an atom of fresh air would be admitted during the hours of sleep. So little is the necessity for good air understood, that we find an able writer on health sanctioning, if not advocating, sleeping with the mouth under the clothes. His argument is that birds sleep with their heads under their wings, and he might have added, many animals with their noses buried in their fur; forgetful, however, that the feathers (and hair) form a natural respirator to *warm and equalize the temperature* of the air that passes freely through. There is therefore no analogy in a process for warming a constant supply of perfectly fresh air, and one for breathing the same air over and over again, and charged *ad nauseam* with organic impurities. Miss Nightingale approaches the subject of night air from the side of reason, and common-sense, and experience. She says:

"Another extraordinary fallacy is the dread of night air. What air can we breathe at night but night air? The choice is between pure night air from without and foul night air from within. Most people prefer the latter. An unaccountable choice. What will they say if it is proved to be true that fully one-half of all the disease we suffer from is occasioned by people sleeping with their windows shut? An open window most nights in the year can never hurt any one. This is not to say that light is not necessary for recovery. In great cities, night air is often the purest and best air to be had in the twenty-four hours. I could better understand in towns shutting the windows during the day than during the night for the sake of the sick. The absence of smoke, the quiet, all tend to making night the best time for airing the patients. One of our highest medical authorities on consumption and climate has told me that the air in London is never so pure as after ten o'clock at night."

These are the words of sound sense and experience. We shall only have to add to them, by-and-by, that it is not necessary to encounter the oftentimes great risk of sudden changes in temperature during the night, if we arrange one principal source of admission day and night to the house, and warm the air admitted. We may further remark that if there be the least ground for shrinking from night air, it is because of the often sudden and unforeseen change in the temperature, the very point overlooked in moving from fireplace to window in modern drawing-rooms.

Latterly some attention has been directed to a plan for diffused ventilation, adopted by Mr. M. Tobin. This plan consists of a series of vertical pipes placed along the walls, delivering fresh air in an upward current. In a multitude of pipes there is safety—much more so than in a multitude of counselors on this subject. Commenting upon this plan of course many critics claim priority of invention, and superiority in their modes of application, and the interests of the public thus go to the wall without any result. It is a pity that it cannot be made intelligible that whoever first opened a window or a door, for the express purpose of admitting air, originated ventilation; and that whoever first made a deeper recess for the lowest sash-bar, so that when the

window was slightly raised the opening would only be where the two sashes overlap, and the admitted air thus thrown upward, originated Mr. Tobin's principle of getting the admitted air diffused in the upper part of the room; and that whoever did this in a room, with apparently no prearranged outlet, first realized the process known by the name of "Tobination."

We believe it was Sydney Smith who declared that if any one in London should stare continuously for a few minutes at the clouds he would be forthwith surrounded by a crowd of gazers, no one knowing why he gazed, intently interested in nothing, and quite unaware that the secret of his sympathy was the inspiration that makes the ploughman whistle—want of thought. For ourselves we do not undervalue this gregarious vacuous tendency. First catch your hare, says good Mrs. Glass, as the initiatory step to cook it. First secure your audience in this matter, as the absolutely necessary preliminary to convince the understanding and stimulate to action. The excitement and satisfaction felt at the recommendation of a mode of ventilation, because perfectly simple and thoroughly efficacious, and yet so obviously similar in its results to window-ventilation, we are disposed to hail as an encouraging symptom, although such satisfaction seems wonderfully like that felt by good King George when he adopted the simple expedient, *under advice*, of shutting his mouth to keep out the dust and dead flies on a windy day!

If the sanction of royalty helped to promote so proper a mode of excluding dust and insects, so, similarly, a report upon "Tobination," signed by six peers and gentlemen, and published in the *Times* on May 16th, may help to recommend the admission of fresh air as a useful method of ventilation. The phenomena attested are certainly surprising in their concurrence, and we cannot but regret that these noblemen and others did not simply state their opinion, which every one would respect, without assigning proofs which most persons must question. "Nae plea is best," say the cautious Scotch, and we are further reminded of the dictum of a wise old friend, "My reasons may be all wrong, but I know that my conclusion is quite right." Now, if the report had simply attested the fact that at a certain time the atmospheric condition of the ward was good, this would have been "nae plea," and best; for the *raison d'être* of the said good atmospheric condition seems to us to be contradictory. What the said six found they thus describe:

"In the ward of St. George's Hospital ventilated by Mr. Tobin's pipes we found the following phenomena:

1. Pure air agreeable to breathe.
2. Absolute equality of temperature at every level of the room, in which gas had been burnt for some time.
3. Freedom from all draught of air. With a lighted taper we could detect no current in any portion of the room."

As we have already indicated, this statement in reference to "the last new thing" in ventilation is, to say the least, puzzling. It virtually asserts the instantaneous and complete mixture of cold air with air heated by and with the gaseous products of combustion, and a simultaneous and necessarily rapid diffusion throughout the entire space of the ward in St. George's Hospital; and that this rapid mingling, mixing movement of particles is done without any perceptible mingling, mixing process, or movement whatever! It thus virtually states that the rapid change of air which alone constitutes perfect ventilation is effected without any ascertainable movement of such air. If such concurrent phenomena be really, as stated, "matters of fact," and not, as we take them to be, the honest but erroneous belief of persons not accustomed to scientific and chemical research, we can only ejaculate like Dominie Sampson—"Pro-di-gi-ous!"

We have so far played the part of critic. We have stated the abstract requirements of perfect ventilation, and have assumed that such requirements are inapplicable to most modern houses. We have condemned the general ignorance and indifference to the proper supply of one of the essentials to existence, and have ridiculed the miserable expedients which pass current under false pretenses. We have further discussed the theory and practice of ventilation mainly distinct from its almost inseparable connection with house-warming. But, unless we are prepared to supply our houses by mechanical contrivances, such as fans, etc., it is impossible practically to consider the thing to be done apart from the obvious means to carry it out; and it is in heat that we find the ever-present and most applicable motive force. If we can give to our houses an average temperature of 55° with local exceptions somewhat in excess of this average, we make them, and particularly the lofty slip of building forming the common London street-house, into a warm air-shaft, having an upward draught. If we can properly arrange and control the entrances and exits of the necessary air, and secure that the supply be ample and the conditions of its motion innocuous, we have solved the problem of practical ventilation.

Any one who can effect this solution will be fairly entitled to the gratitude of all ranks and classes of society—excepting, perhaps, that of the medical profession! And whoever does this by a simple method—without using any scientific complications, and requiring no surrender of the average comprehension to the keeping of mechanical experts—who can reconcile sentiment with common-sense, and economy with the Epicureanism of our present civilization, and who yields no vantage-ground to servantgalism to demand higher wages, nor otherwise trenches upon the time-honored privileges of the servants' hall (to do little in the easiest way)—will have established a claim to social gratitude. The danger he will incur will be in the shape of a testimonial, which will most likely make Art shiver, and the descend-

ants of the receiver despise the ability of the progenitor which handed down to them a thing they hate to keep and dare not sell.

There is a hades, moreover, for inventors and teachers, as well as a paradise. Like people who write books, they give their enemies an advantage. The detailing of their plans is like dragging a coat at Donnybrook Fair. They invite attack from every one whose interests they jostle, or whose pride they wound; and hurt feelings are a species of cantharides to hostile criticism. Altogether, the man who steps ahead of the crowd is marked out for assault. He quits a comfortable insignificance, and, bidding for fame, usually achieves failure and gains ill-will.

Clearly comprehending the possible results, we nevertheless venture to speak of a combined system of warming and ventilation which, from experience, we can state has proved successful. It aims at surcharging a house with warm air, in reversal of the present custom of exhaustion. Ventilation is movement of air, or draughts; and cold draughts are dangerous, and expensive. We therefore warm our draughts, and, in lieu of enemies, make of them friends. By superseding the necessity for it, we put bad workmanship into its proper category of things to be avoided. A house being full of warm air, misfits and scamped work form outlets, not inlets, and are no longer mischievous. By generating heat in the most scientific way, and retaining the bulk of it in the dwelling instead of sending ninety per cent. up the chimney, we enlist the sympathy of the thrifty; and, by considering the question from the house-maid's point of view, we avoid irritation and bickering, and, in spite of new-fangled arrangements—

"We still have peace at home."

Our plan is simply this: If the basement be dry and eligible, we form therein a fresh-air chamber by boarding off or otherwise making it, if possible, under the staircase-hall. We have it carefully cleansed, whitewashed, and purified. We jealously isolate it from any illicit communication with the usually damp and fusty atmosphere of ordinary basement premises, but give to it an ample communication with the outer air, being careful that the supply is drawn from untainted sources. Between this chamber and the hall we also arrange a communication through a large ornamental iron grid.

Immediately under the grid in the air-chamber we have placed a large slow-combustion coke or German stove, and to prevent dust, noise, or effluvium during such lighting, we recommend a slide, or trap-door opening downward, to cut off communication until the fire has burnt up. *Voilà tout!* This simple arrangement, which does not merit the name of apparatus, sets a system of ventilation to work for which we claim the merit of efficiency, by merely lighting and adjusting the stove-fire. Of course everybody has thought of this, and we dare say some persons have tried some such arrangement; but we question whether it has not been hitherto too simple for enthusiasts, too prac-

tical for theorists, and in its results too philosophical for "practical men."

A grid with a clear opening of two to two and a half feet square, through which air is sent at the rate of three feet per second, will change the entire atmosphere of an ordinary London house every hour; and a good-sized coke or well-constructed German stove will heat this volume of air from 65° to 70°, and maintain a temperature throughout such house of 50° to 55°.

The bulk of the heat so generated will be utilized and diffused. The excessive loss of heat from fireplaces will be changed to use, and economy will be the rule instead of a waste—excessive, continuous, and expensive. And the whole of it will be in substitution—not in excess—of an undisturbed open fire-grate consumption of fuel, and this by a process of natural selection and persuasion. With a fairly equable temperature of 50° to 55° throughout the house, and highest where now it is usually lowest—the hall and passages—the demand for large open fires subsides. Small fires become the rule, and their going out the difficulty. There will be no dread of draughts from open doors; no peevish injunctions to "shut that door;" no huddling over a hot fire, scorched on one side and chilled on the other; no breathing at one moment of air at 100°, and the next, and without preparation or much gradation, one of 40°. In short, "the bull will be taken by the horns" *and tamed.* We have made friends of our foes, and we may cry Eureka!—for the problem will be solved!

Now for the possible objections. We shall probably be told that stoves are unwholesome—that they spoil the air and make the warmed space "close." Our reply is, that stoves in unventilated rooms do all this, and more. They are usually unsightly, and they—even the most economical—rob the room of the bright, cheerful, moral influence of warmth with light. But none of the objections to which stoves are liable attach to their use under the arrangement we advocate. The stove is not placed in an unventilated room, *but in a strong draught.* No particle of air ever gets warmed twice over. None is *forced* into contiguity with the heating surface. It takes up as it passes that surface its modicum of caloric, and wings it way to impart it to all and every thing of a lower temperature than itself; and finally it escapes, when fairly deprived of it, by nicks and crannies and illegitimate outlets, as well as by those prearranged for the best effect. Hence there are no whistling shreds of frosty air, harbingers of colds, catarrhs, toothache, earache, and neuralgic inflictions; no "sulphuring" from down-draughts in unused bedroom-fires; no shiversome "draughts" from open doors. By admitting air round about our heat-generator, full, free, and unconfined, we adopt the principle of the steam-engine governor. If the stove be overheated from negligence, the draught becomes quicker, the particles of air are heated sooner, but not necessarily much more. If the stove-fire is allowed to get low, each par-

ticle of air lingers longer, until warmed enough to set off on its errand of ventilation and warming. Variations of heat in the stove quicken or retard the unconfined and full current rather than vary the heat of each particle, and we claim to accomplish by a self-acting process a fair uniformity of temperature.

It will, no doubt, be urged that a house kept up to 50° and 55° makes people "delicate;" that they "catch cold" when they go out; that a hardening process is healthy, and so on.

Our reply is, that a uniform temperature of 50° and 55° is natural and healthy. That the maintenance of this temperature in winter must be a question of clothes or fuel on the one hand, or of depressed functional action on the other. That the loving care which prescribes a cold bedroom and a hot, sweltering bed is of the nature of that kindness that kills. That children buried in blankets realize Prince Bismarck's coarse threat to the Parisians: that their delicate skins become overheated and relaxed while they are irritated by perspiration; at the same time that the most delicate tissues of all, in the lungs, are dealing with air abnormally frigid. Fevered or relaxed, the poor little victims of combined ignorance and kindness toss and dream, troubled under a mass of bedclothes, while the well-meaning mother, "wrapped in her virtue," and soothed by a bedroom-fire, slumbers peacefully through the working out of the sad process of "the survival of the fittest."

The only other objection to be urged against the use of a stove is the small part that the combustion of the fuel in it plays in the matter of ventilation. As the ventilation by means of an open-air fireplace is the principal cause of the waste of heat up the chimney, we cannot consider this gain from arrested waste as an objection, except in extreme cases of stove-misplacement. As, in the plan we are considering, the stove is the agent to supply a very large quantity of air, the plea that it does not abstract any large volume, we take to be an advantage, not an evil. The open fires become the chief diffusers, drawing the injected air within and then out of each room. We concede their employment to the claims of luxury as wasteful adjuncts, but minister still to comfort and luxury. At the same time we legitimatize their action and leave them free to work. We are no longer at enmity with Nature; no longer spoiled children of civilization, struggling against "what is good for us;" but, freely accepting the imposed conditions of an artificial life, we use reason and common-sense to make them the best of their kind. We cook our air as we cook our food. Both in a raw state are objectionable. Both subjected to the modifying influence of heat become pleasant ministers to our daily wants. One generates the blood which is the life, the other is its purifier and renovator. The use of both is health, vigor, and enjoyment; the abuse of either counts up largely in the account we have to pay for what of evil there is in the world.—*Abridged from Westminster Review.*

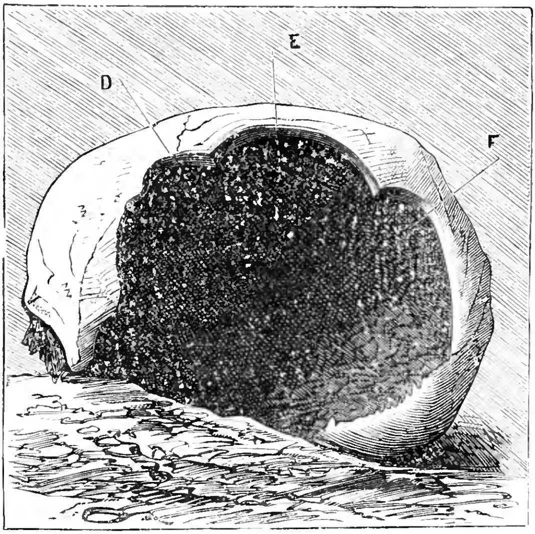
# CRANIAL AMULETS.

By Dr. J. BERTILLON.

TILL the other day nothing was known that would indicate the existence of a religion among the people of the Stone Age. But a little over a year ago there were discovered clear traces of a *cultus*, the most ancient of which we have any idea. I propose here to narrate how we gained our first knowledge of the gross and oftentimes savage superstitions of our early ancestors. This important discovery was made by Dr. Prunières, of Marvejols. As he was cleaning some skulls from the dolmens of Lozère, he found in the interior of one of them a bone disk carefully polished on the edges, and evidently made of a fragment of a cranium, perhaps of the parietal bone. The skull in which this disk was found presented a great hole, through which it might have passed; still evidently it had not come from the part destroyed, being considerably thicker than the other bones of the skull, and, furthermore, differing from them in color. On examining this cranium at the point where it was mutilated, the edges of the opening were found to be carefully polished and beveled on the external surface, and it was plain that the hole itself, like the disk of bone, had been wrought by the hand of man. Was it also man who put the bone disk inside of the skull? One might think at first that it was the effect of an accident similar to that by which the beads of a necklace often drop into the skull; but, when other pieces were discovered similar to that described, it could not be doubted that it was the hand of man which placed the disk of bone in the skull. What was the intention? It is impossible to say with certainty, but it is difficult not to believe that the practice was coupled with a religious idea.

A number of skulls found by M. Prunières presented an opening more or less large, but contained no bone disk. These openings are often the size of a silver dollar, of variable form, but usually circular. That which has excited the greatest astonishment, however, is the fact that these perforations had been made during life, for their beveled edges had evidently commenced to cicatrize; often, indeed, the loss of substance was entirely restored. The *savants* to whom M. Prunières communicated his discovery then remembered that in many skulls they too had observed similar holes, with the edges more or less cicatrized. Up to that time they had supposed that they resulted from strokes of a hatchet dealt by an athletic arm, just as now a sabre often removes a portion of the skull. But what strength are we to imagine the men of that time to have possessed in order to make such terrible wounds with a simple stone hatchet? Hence the explanation offered was not very satisfactory. All doubts were set at rest by the invaluable discoveries of M. Prunières, as interpreted by himself with rare

sagacity. The theory of these holes being the result of a blow from a stone hatchet is indeed extremely improbable in itself; then, too, why should skulls so disfigured be found in such numbers at Marvejols?




Perforated Cranium from Lozère.

Evidently these perforations were made by the hand of man, and with some design; or, to speak more plainly, these people trepanned one another. For what motive did they practise this painful and often fatal operation? Numerous hypotheses have been put forward. Some suppose, with a fair degree of probability, that it had a therapeutic object. The trepan, indeed, has been practised from the most remote antiquity. Hippocrates speaks of it as an operation widely diffused; and, although the father of medicine is in the habit of citing authorities, and of naming the inventors of operations, he does not tell us the name of the originator of trepanning, which leads us to think that his name was not known, because it was lost in the night of time. It is true that the name, from *τρεπω, I turn*, indicates that, when it was admitted into Greek surgery, it was performed, as it is now, by the aid of a centre-bit; still, in primitive times ruder methods were no doubt employed. The trepan was in great repute among the Greeks, and during the middle ages was resorted to for the cure of a number of maladies. The same practice widely prevails at the present time among uncivilized races.

M. le Baron de Larrey, in a note communicated to the Paris Academy of Medicine, relates that the Kabyles still frequently practise the operation, making with a saw four cuts in the shape of a parallelogram. General Faidherbe has sent to the Laboratoire des hautes

Études two skulls from Roknia, Algiers, with traces of this operation. Mr. Squier presented to the Society of Anthropology a skull from an ancient Peruvian grave, upon which are distinctly seen the eight extremities of these saw-cuts. The traces of inflammation around the bone prove that the operation was performed about a week before death. If the person had survived some years, the traces of incision would have been effaced, the four angles would have become rounded, and the result would have resembled those which we now find upon the skulls of Lozère.

M. Chil related, at the Congrès at Lille, that there had been found a perforated skull resembling those discovered by M. Prunières in the Canary Islands—a fact of great importance, if confirmed, for it would indicate that these islands were peopled by African negroes.

The *Medical Times* assures us that the medicine-men of the South-Sea Islands practise, with a bit of glass, trepanning for troubles of the head, such as vertigo, neuralgia, etc. The remedy consists in making a T-shaped incision in the scalp, and scraping the skull with a fragment of glass, until the dura mater is reached, and a hole made one inch in diameter. In the minds of these savages the healing art is mixed up with a multitude of singular religious ideas. In their eyes the maladies of the body are caused by demoniacal possession. Therefore, when one suffers in the head, we must open a passage to let the demon out. It was thus that Jupiter, suffering from headache, escaped the malady by causing Vulcan to strike him so violently that Minerva, Goddess of Wisdom, sprang from the opening.

Hence it may be that, for medical reasons, the men of the Stone Age trepanned the skull. But this does not account for all the facts. Why trepan the dead? Why introduce into some skulls the round plates of bone? It is clear that the healing art had nothing to do with these *post-mortem* operations, and that here our forefathers were simply acting in obedience to some religious ideas which it is hard for us to imagine.

In the first place, we would observe that, in all probability, these people had a religion. M. Joseph, of Baye, has communicated to the Société d'Anthropologie a discovery made at Baye (Marne) of artificial grottoes excavated in the chalk during the Neolithic Age. He saw upon the walls of these caverns rude and almost shapeless sketches representing divinities in human form; and in these same caverns he found skulls perforated similarly to those of M. Prunières. Upon these grounds we may safely argue the existence of a system of religion. It has been observed that all the operations of trepanning were performed either upon infants or upon youths. "Why were not all ages subject to it? why only infants or youths? I hazard the conjecture that it was connected with some superstition, that it formed a part of the ceremony of initiation to some priestly order. This, it is true, presupposes the existence of a religious caste; but there is no doubt

that the neolithic peoples had an organized religious system. These rude sculptures, ever repeated exactly, which represent a female divinity upon the walls of the grottoes of Baye, even prove that the religion of Neolithic times had risen to the height of anthropomorphism. Now, a clearly-defined deity, a god in human form, must have priests that are regularly initiated; and a surgical initiatory rite recurs over and over again even among civilized peoples. Is it objected that the cranial mutilations were of too dangerous a character to be practised in religious ceremonies? But *per se* trepanning is not a dangerous operation. Very frequently, no doubt, it is fatal, but the reason is, because it is resorted to only in the last extremity. It is not the trepanning which kills the patient, but the cerebral lesions, which we seek to relieve in this way. Apart from these complications, its dangers are not very great. On the other hand, religious enthusiasm knows no bounds; and if certain deities exact human sacrifices, certainly those should be considered lenient who require of a man only a piece of his skull. What is piercing the skull, compared with disemboweling? And yet it is known that, among the negroes of Western Africa, certain individuals, to secure initiation in sainthood, and to prove the virtue of their amulets or *gree-grees*, open their bellies with their own hands, pull their bowels out, put them back, and sew themselves up. Many succumb to this butchery, but others rally and become the saints of their tribe." ("Bulletin de la Société d'Anthropologie," 2e série, tome ix., p. 199.)

Doubtless those who survived the piercing of the skull became equally worshipful personages, held in honor during their lives and after their deaths. Out of their sacred skulls were cut plates of bone, as shown in the engraving. They were then kept as sacred relics, or even worn as amulets, for many of them are pierced through the centre evidently with the view of suspending them. The skull in the figure has undergone three mutilations, *D*, *E*, and *F*, doubtless for the purpose of making amulets. Nor ought we to deride this superstition which attaches supernatural virtue to a bone from the human head: as late as the last century, a powder made from certain bones of the cranium used to be prescribed as a cure for epilepsy. It has been remarked that all the skulls in which disks of bone were found, were pierced during the life of the individual. If our hypothesis be true, the only ones honored with this practice would have been those consecrated to the service of the gods. If, on the other hand, motives be sought wherefore the dead should be thus honored, we are irresistibly conducted to their steadfast faith in the immortality of the soul. A person who had been trepanned comes to die—one or more pieces are cut from his sacred cranium for amulets or relics; but, inasmuch as the man could not live in another world with a mutilated skull, another piece of skull is given him to make him whole, when he reaches the abode of the blest.—*La Nature.*

# THE USE OF NARCOTICS.

THE indulgence in narcotics—something to dull, stupefy, and soothe the nervous system—is a predominant human weakness. Nature has been ransacked for narcotics. Tobacco, opium, betel-nut, Indian hemp, even some kinds of fungi, are employed for the desired object. When tobacco was first introduced into Europe, its use was nearly everywhere looked upon with dislike by the authorities. The efforts that were made to suppress it amounted to nothing less than persecution, and their want of success furnishes a curious illustration of the uselessness of legislative interference with the individual's legitimate freedom of action. It serves also to illustrate in some measure the strong hold which the taste for narcotics obtains over the mind, especially as tobacco is one of the mildest narcotics in use. Among ourselves, not to mention King James's well-known "Counterblast," many petty restrictions were laid on the sale of tobacco during that monarch's reign, and the import duty was raised from twopence to six shillings and tenpence a pound. In England and elsewhere, remonstrance and penalties were equally unavailing. Tobacco made its way steadily into favor, and is believed to be now in use among not less than 800,000,000 of the human race.

Measures of a severe nature have been tried in China to check the use of opium, and have been quite as unsuccessful. However apathetic the Chinese may be in respect to most things, they will not submit to the withdrawal of their favorite narcotic. But in case of so dangerous a poison, some restrictions are as much needed as they are on the sale of spirituous liquors among ourselves; for the effects of habitual excess are not less deplorable than those of habitual drunkenness. Of forty prisoners confined in the House of Correction at Singapore, thirty-five were found to use opium; and of these, seventeen, who had been in receipt of eighteen shillings a month as wages, spent twenty-four shillings for opium, the difference being obtained by theft. From a sanitary point of view, the results are equally sad. The confirmed opium-eater in the East seldom lives beyond the age of forty, and may be recognized at a glance by his trembling steps and curved spine, his sunken, glassy eyes and sallow, withered features. The muscles, too, of his neck and fingers often become contracted. Yet incurring even this penalty will enable him to indulge his vice only for a certain length of time. Unlike the healthy enjoyment which we derive from our appetite of hunger, and which Nature herself renews periodically, the enjoyment of the opium-eater gradually diminishes as his system becomes habituated to the drug. From time to time he must increase the quantity which he takes, but at length no increase will produce any effect. Under these circumstances he has

recourse to a dangerous expedient: he mixes a small quantity of corrosive sublimate with the opium, the influence of which is thus for a time renewed. Then these means also fail; when the victim must bear the miserable condition to which he is reduced, until probably, sooner or later, he sinks into the grave. On the excitable temperament of the Malays and Javanese, a strong dose of opium causes a state of frantic fury amounting almost to madness, and this often ends in that homicidal mania which has been called "running amuck;" in other words, in the individual attacking with his crease or dagger every one whom he meets, so that it becomes necessary to shoot him down with as little compunction as we do a mad dog. In Java, opium is not allowed to be sold except in an adulterated form, the risk of these evil consequences being thus in some measure lessened.

So far as the effects of opium on the system are concerned, it is almost entirely a matter of indifference in what way the drug is used. Whether it be taken in the solid form of pills, in the liquid form of laudanum, or inhaled from a pipe as heated vapor, it speedily exerts its pernicious and almost irresistible influence over the mind; so that few possess the iron will needed to relinquish the habit when it has once been fairly acquired. How completely even the most intellectual and cultivated minds may become enslaved was well illustrated in the cases of Coleridge and De Quincey, whose highly-colored descriptions of their experiences are said to have been productive of much evil among the educated classes of this country. These descriptions must not, however, be regarded as safe criteria of the usual influence of opium on the colder temperament of the North European. According to Dr. Christison, it seldom produces a more striking effect on the Anglo-Saxon constitution than the removal of torpor and sluggishness, thus rendering the opium-eater a pleasant and conversable companion; but these small advantages, in turn, are purchased by a period of subsequent pain and depression, the misery of which it would be difficult to exaggerate.

Opium, besides acting as a narcotic, possesses a remarkable power as a restorative. By apparently checking the natural waste of nervous energy, it enables the system to support fatigue, beneath which it must otherwise inevitably have sunk. For this reason it is much used by the Halcarras, the palanquin-bearers and messengers of India, who journey almost incredible distances, furnished with nothing more than a bag of rice, a little opium, and a pot to draw water from the wells. The Tartar couriers also use it to sustain them, when compelled to travel night and day in crossing the arid deserts of Central Asia; and in some parts of the East it is administered as a restorative even to horses.

It is difficult to come to any definite conclusion as to whether the physical character of Eastern races who habitually use opium as a narcotic has deteriorated in consequence. No doubt the general be-

lief is that even moderate indulgence must necessarily be injurious, and it is easy to point to the enervated character of the Turks and other Oriental races as a probable result of the habit. But at the same time it is a disputed point among physiologists how far this belief correctly represents the truth. The opinions of many men well acquainted with the East might be quoted in opposition to it; for example, Dr. Eatwell, formerly of the East India Company's service, in writing to the *Pharmaceutical Journal*, has affirmed that, as regards the great mass of the Chinese, no injurious effects of the opium they consume can be noticed, the people being generally a muscular and well-formed race. Dr. Macpherson has given similar testimony in respect to the Chinese, and Dr. Burnes in respect to the natives of Scinde and Cutch; while, on the other hand, Dr. Little, of Singapore, is of opinion that the native population of that island would be in danger of becoming extinct from the use of opiates, were it not constantly recruited by immigration. It is, however, evident that the question can only be satisfactorily answered by knowing the real extent to which opium-eating prevails among the different Eastern populations, and of this no reliable statistics can be obtained.

There is a similar want of definite information in respect to the United Kingdom. Attention was partially drawn to the subject so long ago as 1844, by an inquiry that was made into the state of large towns in Lancashire; and since that time there is every reason to believe that the evil has largely augmented. The increase in the quantities of the raw material imported would alone be sufficient to render this probable; for, while in 1852 the importation amounted to 114,000 pounds, it had grown to 356,000 pounds in 1872. No doubt a large portion of this enormous quantity is employed in the manufacture of morphia or other alkaloids, and is either exported or employed for legitimate medicinal purposes; but it is difficult to account for an increase in twenty years of 200 per cent., except on the supposition that the drug is *more largely used as a narcotic than is generally believed*. The facility with which this form of vice can be concealed renders direct evidence on the subject difficult to obtain; but such evidence as can be procured tends to prove that the above supposition is correct. We have recently been informed by the medical attendant to the workhouse in one of our larger cities, that a week rarely passes without a case of opium-eating coming to his knowledge among those who seek admission to the workhouse; and that he has known women, when suffering from the depression consequent upon their enforced abstinence, even go down on their knees to beg that he would administer to them an opiate. Again, there is reason to believe that opium is a favorite stimulant with many underfed and overworked artisans and laborers; and from inquiries made by parochial officials, clergymen, and others, this would appear to be especially the case in agricultural districts. In the fenny districts of Lincolnshire, a belief being preva-

lent that opium acts as a preservative against the effects of a damp climate, many of the inhabitants have in this way become addicted to its use.

Another and even more reprehensible form of the opium evil among the lower classes is to be found in the practice of administering soothing mixtures to young children for the purpose of keeping them quiet. In one instance, a mother, because her child was unwell, has been known to place a piece of crude opium in its mouth to suck, the death of the child being naturally the consequence; and though cases of such gross and culpable ignorance as this are no doubt rare, it is certain that the administration of soothing sirups and cordials is too commonly resorted to. In large manufacturing towns, where mothers are often employed in factories during the day, their infants are frequently placed for the time in the care of nurses; and these women seldom feel any compunction in administering an opiate to a child who is troublesome. It cannot be too widely known how greatly such a practice tends not only to the direct increase of infant mortality, but also to the permanent injury of the constitution, by inducing convulsions and other similar nervous diseases.

Opium in one of its forms enters largely into the composition of many of the pain-killers and patent medicines so freely advertised for domestic use in the present day, and for this reason the greatest care is needed in having recourse to any of them. Taken, perhaps, in the first instance, to alleviate the torments of neuralgia or toothache, what proves to be a remedy soon becomes a source of gratification, which the wretchedness that follows on abstinence renders increasingly difficult to lay aside. The same must be said of narcotics, such as bromide of potassium and hydrate of chloral, frequently resorted to as a remedy for sleeplessness: the system quickly becomes habituated to their use, and they can then be relinquished only at the cost of much suffering. Indeed, the last-mentioned of these two drugs obtains over the mind a power which may be compared to that of opium, and is, moreover, liable to occasion the disease known as chloralism, by which the system ultimately becomes a complete wreck.

Looking at the whole question of the medicinal use of narcotics, it is perhaps not too much to say that they should never be employed except with the authority of a competent medical adviser.

Turning again to the narcotics of savage or but semi-civilized races, we find a species of fungus (*Amanita muscaria*) employed by the natives of Kamtchatka and the adjoining provinces of Siberia. It grows plentifully in parts of Kamtchatka, and is there generally prepared for use in several ways. The inhabitants either gather it during the hottest months, and hang it in strings to dry in the open air, or leave it to ripen and dry in the ground, when it possesses stronger narcotic qualities. Small-sized specimens, covered with warty excrescences and deeply-colored, are also considered more valuable than

the smooth pale ones. Sometimes it is eaten in soups and sauces, or is taken mixed with the juice of the whortleberry; but the more usual method is to swallow it whole, rolled into the form of a pill, and a single large-sized toadstool thus taken is sufficient to cause the narcotic effects during a whole day. These bear a very close resemblance to those of ordinary intoxication, and, like them, often end in complete insensibility. Whatever may be the natural temperament of the individual shows itself with unusual distinctness. A man who is fond of music or of talking will be constantly singing or chattering; and secrets often thus slip out, the disclosure of which is the source of much subsequent trouble. In this form of narcotism, too, the power of estimating the size of objects is temporarily destroyed, so that a man wishing to step across a straw or a small twig will raise his foot as though about to step across the trunk of a tree.

The Siberian fungus is not the only narcotic in which this last peculiarity is found. Similar erroneous impressions are caused by the Indian hemp, which, though it is used in Southwestern Asia, and indeed in the Brazils as well, is more properly the narcotic of the African Continent, where it is known to the native races from the Mediterranean to the Cape of Good Hope. It is the same plant that is grown in Europe for the sake of its valuable fibre; for, though probably indigenous to India, it is able, like the potato and the tobacco plant, to adapt itself to a great variety of climates, and is grown even in the north of Russia. Its narcotic virtues depend on a resinous substance contained in the sap; and this is much more abundant in tropical climates than it is in temperate. Indeed, the European plant is almost devoid of it, though it possesses a strong odor which has been known to make people ill who have remained long in a hemp-field. Thus, when the dried plant is either smoked or eaten, its effects are both rapid and powerful. In Morocco, where the dried flowers are generally smoked, a single pipe not larger than an ordinary tobacco-pipe is sufficient to intoxicate. Among the Arabs and Syrians, the usual method is to boil the leaves and flowers in water mixed with butter to the consistence of a sirup, which is called *hasheesh*, and, as it has an extremely disagreeable taste, is eaten in a confection of cloves, nutmegs, and other spices. But however the narcotic may be used, the pleasure it affords is much the same in character. It has been described as consisting in "an intense feeling of happiness, which attends all the operations of the mind. The sun shines on every thought that passes through the brain, and every movement of the body is the source of enjoyment." But the most remarkable peculiarity of the Indian hemp has yet to be mentioned: a dose of the resin has been known to occasion that strange condition of the nervous system called catalepsy, in which, notwithstanding the force of gravity, the limbs of the unconscious patient remain stationary in whatever position they may be placed.

The use of the coca-tree as a narcotic in Peru and Bolivia is of very great antiquity. When the Spaniards landed under Pizarro, they found the natives chewing the dried leaves, in exactly the same way in which they have continued to chew them down to the present day. Efforts were indeed made, soon after the subjugation of the country, to put a stop to the practice, for the plant had acted an important part in the Peruvian religious ceremonies, and its use was looked upon by the conquerors as an obstacle to the spread of Christianity. Nevertheless, the Indians persevered in spite of every prohibition and severity. Before long, too, the owners of mines and plantations discovered that it was to their interest to connive at the habit, as, with its aid, their laborers were able to perform more work on a given quantity of food than they could do without it. It has thus gradually become the universal custom to allow from fifteen to thirty minutes, three or four times a day, for the purpose of chewing. At these times the first object of the Indian is to make himself as comfortable as possible, for the coca fails to produce its effect unless the chewer be perfectly quiescent. He stretches himself at full length in the shade, on a couch of dry leaves or soft turf, and, rolling a few of the coca-leaves into a ball, conveys them into his mouth; adding immediately, to bring out the full flavor, a small quantity of unslacked lime, or of the alkaline ashes of certain plants. When thus engaged, the apathy he displays to every thing around him is something marvelous. No entreaty on the part of his employer will induce him to move, and, if he be a confirmed *coquero*, he is indifferent even to drenching rain or the roar of wild animals in the neighboring thicket. In what way the pleasures of the coca-leaf manifest themselves is not known, but they must evidently be of a very seducing kind, thus to render men insensible to personal danger.

Notwithstanding the wide prevalence of the use of narcotics, little or nothing is known of the way in which their different effects are produced on the system; and the problem is complicated by the number of active substances that enter into their composition. Opium, besides other more ordinary ingredients, contains no fewer than eleven peculiar organic compounds, all of which are believed to share in producing its usual effects. It has, however, been noticed that many symptoms of narcotism bear a close resemblance to those of insanity. The wild laughter of a man under the influence of the deadly nightshade cannot be distinguished from that of a manaic, and the false impressions as to the size of objects, caused by the Indian hemp and the Siberian fungus, are a permanent feature in the malady of many lunatics. It has been suggested by Dr. Carpenter that much light might be thrown on the connection between the mind and the body by studying the phenomena of drunkenness, and it seems probable that those of narcotism in different parts of the world might be made to yield equally rich results. Of one thing we may be quite certain. The use

of tobacco has become a positive vice. The wastefulness of money which it causes, without a compensatory advantage, is alone deplorable.—*Chambers's Journal.*

## SKETCH OF PROFESSOR HILGARD.

WE this month present to our readers the portrait of Julius E. Hilgard, First Assistant of the United States Coast Survey, and President of the American Association for the Advancement of Science at the meeting in Detroit, which takes place on the 11th of August of the present year. Mr. Hilgard was born in January, 1825, in the town of Zweibrücken, in Bavaria, where his father held the position of Judge of the Court of Appeals for the Palatinate of the Rhine. At the age of nine years he came to the United States with his father, who settled on a farm near Belleville, Illinois, where his education, classical and mathematical, was continued by parental instruction, aided by the part he took in the education of several younger brothers. At the age of eighteen he went to Philadelphia, and pursued the study of civil engineering under the advice of such eminent engineers as Roberts and Trautwine. His ardent desire for knowledge attracted the attention of Dr. Patterson, Prof. Bache, and other members of the Philosophical Society; and, soon after Prof. Bache took charge of the Coast Survey, he attached young Hilgard to the corps of assistants which he was about to form, and which, under his training, has attained so eminent a position as a scientific body. Hilgard was soon recognized as one of the leading spirits of the work, and by zeal in active service, untiring application, and the improvement wrought in all branches of the work that he touched, rose to the position of Chief of the Bureau of the Coast Survey at headquarters in Washington. To this position, which he holds at the present time, he was assigned at the beginning of the war of the rebellion, which called forth the best efforts of every member of the Coast Survey, and brought into play its resources of important information gathered during previous years.

Mr. Hilgard's scientific work has chiefly been in connection with his practical labors, consisting of researches and discussion of results in geodesy and terrestrial physics, and in perfecting methods and instrumental means connected with the same. The annual reports of the Coast Survey contain numerous papers from his hand on the application of the method of least squares to geodesy, on determinations of latitude, azimuth, and longitude; on methods of precision in measuring lengths, and on terrestrial magnetism. In 1872 he executed, in connection with the telegraphic determination of the longitude between America and Europe through the French cable, a similar de-

termination between the observatories at Paris and Greenwich, which supersedes the value previously admitted, correcting it by nearly half a second of time. His essay on "Tides and Tidal Action in Harbors," first published as a lecture before the American Institute, is remarkable for its lucid and terse exposition of principles without the aid of mathematical symbols. While possessing great facility in employing the aid of the higher mathematics, Mr. Hilgard systematically avoids, as far as practicable, their introduction in his writings, preferring to use logical statements of the processes of reasoning.

As part of the duties of his office, Mr. Hilgard has charge of the construction and verification of the standards of weight and measure for the United States, and, by order of Congress, has been for some years past engaged in preparing metrical standards of great precision for distribution to the several States. In this connection he was appointed a delegate to the International Metrical Commission, which met at Paris in 1872, having for its object the construction of new metrical prototypes of great precision and permanence, and which has since resulted in the establishment of an International Bureau of Weights and Measures at Paris, under the direction of a committee, of which Mr. Hilgard is a member. A valuable and instructive treatise on "Methods of Precision in measuring and weighing" was read by him before the Stevens Institute of Technology, but has not yet been published.

When, in 1863, the National Academy of Sciences was chartered by Congress, Mr. Hilgard was one of the original members named in the act. He is at present the home secretary of that scientific body. The compliment of honorary membership has been conferred upon him by the American Philosophical Society of Philadelphia, and the Academy of Arts and Sciences of Boston. His frequent communications to the Philosophical Society of Washington are evidence of a very active interest in scientific research, maintained notwithstanding the exactions of his arduous official labors. A work of great interest, which he is now conducting outside of his official sphere, is a magnetic survey of the United States, prosecuted at the expense of the Bache Fund, arising from a bequest of the late Alexander Dallas Bache to the National Academy of Sciences.

No small part of Mr. Hilgard's services to science and education is to be found in the readiness and obliging disposition with which he has constantly given information and rendered facilities by the loan of instruments and apparatus to persons engaged in scientific research or instruction. Besides meeting numerous requests of this kind at home, he has given his best aid and advice to the equipment of government surveys in the Sandwich Islands and in Japan. Although Mr. Hilgard's scientific work has been generally limited to the sphere embraced in his practical pursuits, he has been a very active student in other branches of science, especially dynamics and molecular physics.

# EDITOR'S TABLE.

## *A SOCIAL EXPERIMENT.*

WE observed, a while ago, the meeting of two gentlemen who, after salutation, broke at once into mutual and vehement expressions of disgust at the Beecher trial, and then sat down and discussed it for an hour. Such has been the general experience. Newspapers have bemoaned the necessity of publication, and then howled for the extension of the proceedings, meantime sending out their interviewers in all directions, to rake the gutters of scandal for further and filthier details. Similarly, by the mass of readers, the reports have been first deplored and then devoured to the last crumb. The protests were hollow concessions to decency; what followed revealed the actual and honest mental condition of the parties.

This aspect of the trial, as an index of public taste, is not without its instructiveness. It was evidently rich in elements that are appreciated by our people, and that take a deep hold of their feelings. It fed the craving for personal and prurient gossip, and, moreover, left something to bet on. It combined, in its various phases, the fascinations of the tea-party, the prize-ring, and the regatta. The lower education, by bringing the masses of the people up to the capacity of reading the newspapers, and the higher education, by allying itself with the horse-racing passion, have well prepared the community to enjoy the drama lately acted on Judge Neilson's stage. True, it was the old story of private suffering turned to public sport, but with what refinements in its modernized aspect! A dash of brutal bloodshed, a little gladiatorial human butchery, were indispensable to the perfection of a Roman holiday; but, in our higher Christian civilization, we get up a six-months' carnival of keen excitement by mangling a single reputation. It is certainly worth something to find out how our people can be best amused.

We are far from agreeing with those who have filled the land with lamentation over the unmitigated evils of the Beecher trial. It has undoubtedly had its mischievous influences, but these we believe will be transient and far outweighed by the public benefits that cannot fail to arise from it. It was, of course, most painful to Mr. Beecher—and he has our deepest sympathy—but no one better than he could afford to make the sacrifice needed to insure the permanent good of such a thoroughgoing social experiment as this trial and its preludes have furnished. The case is of peculiar interest as a problem of the forces acting in society. It is a great mistake to suppose that the Plymouth pastor was alone on trial. Action and reaction are equal and opposite in things social as well as in things physical. The strain took effect all round; and the triers have been on trial as well as the defendant. We know a great deal more about lawyers and the law than we did before; we understand better about judges and the judiciary than we did before; and we have conceptions of the jury and the jury-system which we had not before; while the result of the new knowledge is not by any means to raise our estimate of them. They have been brought to the bar of common-sense and the public judgment, and nothing has happened in the history of legal proceedings in this country that can compare with this case in exposing the weakness, the anomalies, and the vices of the system under which we live, called the perfection of reason, for the administration of justice. Nowhere in society are in-

congruity and absurdity so deeply intrenched as in law and law administration, while the acutest and most powerful of the professions forms the body-guard and bulwark of the system. But of this we are little disposed to complain. To conserve the good we must tolerate the concomitant evil; and there is neither intelligence, wisdom, nor honesty enough in the country to make a better system. If we are ever to get out of it, we must slowly grow out; and nothing will facilitate this more than such a shaking up and exposure of our judicial doings before the world as this remarkable trial has just effected.

But, aside from its personal issues, the case has chiefly interested us as a test of popular intelligence, and as affording an instructive illustration of the way people form opinions. The opinions of the multitude are commonly inherited or adopted; they are rarely "formed" by rational processes, and whenever the attempt to form them is made under proper circumstances, we get the best possible measure of mental capacity, integrity, and the efficacy of education. The Beecher case was well suited to be an ordeal of popular judgment. It was a fresh question, without precedents, and had to be accepted upon its merits. Then it was an open question, or early so regarded by the public, and so entertained by the court. Besides, it was a complex question, well fitted to task mental effort, and it dealt with human motives, conduct, and character, elements belonging to the common experience of mankind. The situation was thus favorable for fair and intelligent judgment; and yet, under these conditions, we get one of the most unexampled lessons as to how little of rationality there is in human thinking, and how little evidence has to do with the formation of popular convictions. Our concern is not here with the issue involved in the trial and which preceded it, but with the way the public approached and dealt with it.

We shall be helped by reference to a rudimentary bit of the science of mind. When men are called rational creatures, if it is meant that they have a capacity of reason by which they can arrive at the truth, the idea is correct; if it is meant that they are characteristically rational or controlled by reason, the idea is quite erroneous. Men are habitually creatures of emotion rather than of intellect. The emotions are the motors or driving forces of our nature; in a few they are guided and governed by the intellect; in the many they are lawless agencies, dominating the intellect and enslaving the rational nature. It is therefore of immensely greater importance to know how men feel than what they think; in fact, the last is generally the consequence of the first. That which lies beyond the reason and the will in the mental constitution, and gets vent continually under the pressure of sentiment, impulse, passion, love, hate, habit, and prejudice, is of immensely greater volume and moment than all that is said or done under the influence of intelligent volition. The perverting influence of passion is well known; but it is equally true that emotions of every kind and degree disturb the intellectual balance. Sympathies and antipathies, hates and admirations, blind the reason, distort the judgment, and reduce the mental experience to the grade of emotional automatism. Men carry on their mental intercourse in terms of reason, and delude themselves with the fancy that they are logical, when in fact they are only venting their preferences or dislikes, or giving excuses for their prepossessions, or exploding their inveterate prejudices.

Now, probably no man has appeared in this country who has stirred up so much adverse feeling of all kinds as Henry Ward Beecher. For twenty-five years he has been more heard and more read than any other person, and has stamped his personality deep in the national mind. From the first he has

taken up subjects of intense popular interest, and has treated them with such boldness and power as to command universal attention. His attitude, moreover, has been such as to provoke partisanship, and arouse antagonism. Independent in theology, free and easy in the pulpit, and often rough upon the churches, he has raised a great deal of religious animosity. A vehement reformer, he has amazed and irritated conservative people. Foremost and often fierce in politics, during a long period of intense political excitement, he has stirred up an enormous amount of political detestation. This disturbing influence has been felt to the remotest corners of the land, but of course it has been more palpable around home. To the general causes of repugnance have been added local causes in his own city that have operated with virulent intensity. He had many and ardent friends whose indiscriminate praises produced revulsion and disgust in many minds. Brother clergymen were gangrened with jealousy at his overshadowing influence, while their congregations were charged with sympathetic spite.

Now, this is a dangerous position for a man to hold in a community, as in any untoward circumstances it could be turned against him with fatal effect. If anybody had a motive or design to unroof Plymouth church, smash the pastor, and drive him out of Brooklyn, the facilities of assault were at hand. It was only necessary to fix upon Mr. Beecher a scandalous charge, and it was sure to spread like fire in straw. It was not at all necessary for purposes of public effect to establish the charge by valid evidence; it was only necessary to link certain ideas together to make a circumstantial picture of scandalous details, with Mr. Beecher as the central figure, and public feeling, consisting largely of dislike, hatred, prejudice, and jealousy, would cement the ideas together and give them all the force and effect of proof. And such is notoriously the way the case was carried. The picture was made by the Woodhulls; and, backed by no better evidence than the Woodhull character, it was at once believed by multitudes in the way they believe most other things. Of course, all those whose estimate of Mr. Beecher was indicated by such terms as "blatherskite," "nigger-worshiper," and "priestly hypocrite," accepted the charge on sight; but with thousands upon thousands of others there was from the first an unavowed half-belief palpably originating in unfavorable feeling. With the great mass of the community, indeed, the case was absolutely prejudged, the "statements" following the Woodhull presentation clinching and closing it, so that the six-months' trial was a mere superfluous appendage. As has been often and truly said, with any other man the case could probably never have got a foothold in a court of justice; but with Beecher the whole country was on fire with excitement, and was determined to have it out; and so, with the coöperation of the newspapers, and an accommodating court, the people have regaled themselves on putrescent gossip for half a year. The possibility of such a social experiment would not have been previously believed; but if it could occur it is better that it should occur, as thereby we become wholesomely, if painfully, instructed in the ways of that curious thing we call public opinion.

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### "*KNOX THE INCOMPARABLE.*"

In another part of this magazine, under the title of "A Popular Verdict," will be found the painful story of one of the remarkable characters of the past generation. The sketch is far too meagre to do justice either to the traits of the man or to the causes that conspired to darken the later portions of his life.

We first became acquainted with the genius of Dr. Robert Knox in 1852, through a work issued in that year, entitled "Great Artists and Great Anatomists: a Biographical and Philosophical Study." It was a small book, but unique and racy to a remarkable degree. Full of erudition, bold, sarcastic, witty, heterodox, and abounding in acute suggestions, it combined fresh biographical glimpses of such men as Cuvier, Geoffroy St.-Hilaire, Da Vinci, Angelo, and Raphael, with an original and philosophical treatment of the art, the literature, and the science of the epochs in which these great characters lived. The humor, freedom, and pungency of this little *brochure* induced us to look further into the writings of this author, and we found in "The Races of Men" a book rich in information, and written in the same vivid and fascinating style. The relations of anatomy to art was a favorite subject with Dr. Knox, and he contributed much toward its development. He published (also in 1852) "A Manual of Artistic Anatomy, for the Use of Sculptors, Painters, and Amateurs," with illustrations by Dr. Westmacott. This work contains a great deal of information, set forth in the author's peculiar style; and the third part of the volume gives an interesting analysis of beauty, a theory of the beautiful, and an exposition of the author's views on the objects and aims of art. The bias of the anatomist, however, is perceptible, as he is disinclined to recognize poetry, music, and the drama, as belonging to the fine arts, shows little favor to architecture, and holds that sculpture alone is entitled to the rank of high art. The most brilliant lecturer of his time in England, he applied, in 1841, for the vacant position of anatomical lecturer to the art-students of the Scottish Academy; but, though strongly backed, he failed as Sir Charles Bell had previously thrice failed in his application for the professorship of anatomy to the Royal Academy in London. Knox failed, though supereminently the man for the place, because an incompetent rival, Mr. James Miller, surgeon, offered his services gratuitously—a consideration which, with the canny Scotch, outweighed all others. Of course, Mr. Miller, at the end of the year, asked for his predecessor's salary, and, after due manipulation and management, obtained it. It was such miserable chicanery and trickiness in education by which "mediocrity gets intrenched and consolidated and founded on adamant," that roused the indignation of Dr. Knox, and led to those scathing denunciations of official and conventional stupidity that did so much to stir up animosity against him. He would call a spade a spade, which, in a state of society despotically ruled by etiquette, was an unpardonable sin.

We have referred to Dr. Knox's work on the "Races of Men," and probably the most powerful cause of that unpopularity that was turned so fatally against him in the hour of his calamity was his early and uncompromising advocacy of the most advanced views upon this subject. He was one of the eminent founders of the modern science of anthropology. Ethnological questions had been systematically entered upon before his time, but the core of the inquiry had hardly yet been reached.

The dissertation of Blumenbach "De Generis Humani Varietate Natura" (1775), was the first great treatise on the races of men, and formed the text-book of Cuvier, Lawrence, Pritchard, Nott and Gliddon, Latham, Waitz, Morton, Pickering, and others. Dr. Knox became an early and independent student of the great problem of the human races, and its comprehensive investigation was a controlling object of his life. He sought to give a new direction to the study of race. He aimed at a knowledge of man in his scientific completeness, geographical, historical, and physical, and as a foundation of such knowledge he wished to have a

record of his normal structures, osteology, and nervous system, with all the deviations, rudimentary, excessive, or abnormal, that methodical observation might furnish. He demanded that man shall be inductively studied throughout his whole nature; and he classified his history with the history of the organic world, as, by unity of organization, connected with all life, past, present, and to come. Dr. Knox took the ground, bold ground half a century ago, of the vast antiquity of man, and, though holding to the Cuvierean view of the immutability of species, he shrank from no opprobrium of beliefs denounced at that time as spurious science, immoral in their influence and destructive of religion. He defended these unpopular views with pungency and power, as was his wont, and as a matter of course called down upon himself the reproachful epithets of "infidel" and "atheist." Where sufficient mud is thrown, some of it is sure to stick. The doctor became obnoxious to the theologians, and was looked upon with dread by the people on account of his horrible opinions; and, when the occurrences took place which are described elsewhere in our pages, he became the ready victim of malignant aspersion. Nearly half a century has now passed since the Edinburgh excitements; "Knox the incomparable," as he was styled by his admiring students, has been years in his grave, and the time has at length come when justice should be done to his memory.

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## LITERARY NOTICES.

THE AËRIAL WORLD. A Popular Account of the Phenomena and Life of the Atmosphere. By G. HARTWIG, M. & P. D. New York: D. Appleton & Co., 1875. Price, $6.00.

As a compend of interesting and valuable information concerning the atmosphere and its phenomena, this book deserves favorable mention. The reading public is familiar with previous publications by Dr. Hartwig, in which he has succeeded in presenting the results of inquiry in several departments of science in a manner at once popular, entertaining, and instructive. It is quite evident that his success as a writer lies in the judicious selection and arrangement of facts and incidents in science rather than in original investigation; and that he is doing excellent service in this direction will be conceded by all acquainted with his books. The time seems to have not yet arrived when scientific knowledge is sought by the general reading public, unless it be made attractive by skillful manipulations.

The present volume is a popular exposition of the science of meteorology, without being a scientific treatise on that subject. The amount of information in it is immense, but it is classified with excellent judgment, and, so far as we have examined it, is accurate in its science. The style is easy, perspicuous, sometimes florid, but always appropriate and pleasing.

The chapters on "Clouds," "Colors of the Sky," "Aërial Navigation," "The St. Elmo's-Fire," "Snow," and some others, are brilliant with descriptive passages. Chapters relating to topics of especial scientific interest are those on "The Magnitude, Pressure, and Ingredients of the Atmosphere," "The Propagation of Sound through it," "Echoes," "Winds," "Fogs," "Dew," "Rain," "Thunder-storms," "Aërolites," etc.

The volume is handsomely illustrated with plates and woodcuts, and a meteorological map.

To the specialist in the science of meteorology, this work may be of comparatively little value. It is not designed for such, and the author modestly observes that his aim has been less ambitious, and that he will not consider his time ill-spent if the perusal of it awakens in the mind of the reader a keener interest in the pages of Nature.

ON BRITISH WILD-FLOWERS, CONSIDERED IN RELATION TO INSECTS. By Sir JOHN LUBBOCK, Bart., F. R. S. With numerous Illustrations. London: Macmillan & Co., 1875. Price, $1.50.

THIS is the seventh volume in "Nature Series," and is a product of a wonderfully

active, capacious, and fertile mind. Few men have accomplished what Sir John Lubbuck has in the departments of ethnology, zoölogy, entomology, and several other branches of science, and are, at the same time, eminent and successful as he is in financial and commercial enterprise.

The present little volume will be read with interest and profit; although, as the author modestly tells us, it is quite incomplete, the subject of it being yet in its infancy. That flowers and insects are intimately related has long been known, but the importance and extent of those relations were scarcely suspected until recent time. "It is our illustrious countryman, Mr. Darwin," the author observes, "who first brought into prominence the fact that the importance of insects to flowers consisted in their transferring the pollen, not merely from the stamens to the pistil, but from the stamens of one flower to the pistils of another. . . . While, then, from time immemorial we have known that flowers are of great importance to insects, it is only of late that we have realized how important, indeed how necessary, insects are to flowers."

These ideas are illustrated and enforced by a series of careful and ingenious observations conducted by the author, "chiefly with the view of encouraging in his children that love of natural history from which he has derived so much happiness."

The work is illustrated by 130 figures, has a glossary, and a copious index.

Statement and Exposition of Certain Harmonies of the Solar System. By Stephen Alexander, LL. D., Professor of Astronomy in the College of New Jersey. Smithsonian Contributions to Knowledge, No. 280. Washington, 1875.

The laws of Kepler declare, with respect to any one planet, that it moves in an ellipse about the sun, which is at one focus of this ellipse, and that the radius-vector of this planet (the line joining it to the sun) sweeps over equal areas in equal times: with respect to any two planets, these laws declare that the squares of their times of revolution about the sun are proportional to the cubes of their mean distances. This last law, as Sir John Herschel has remarked, binds all the planets together and gives to their motions a family likeness.

Conversely, if we inquire what law of central force will cause two planets to obey the laws just quoted, we find that this central force must vary in intensity inversely as the square of the distance. Given Kepler's laws, we can arrive at this law of force: assuming this law of force, Kepler's laws are a consequence.

Now, if in the planetary system we inquire what are the further laws, if any, which the members each fulfill, we find that there are resemblances, analogies, harmonies, but no *exact* laws which govern the masses, densities, rotation-periods, distances, etc. The law of Titius (or Bode's law) gave numbers which approximated to the mean distances of the major planets, until Neptune was discovered, the mean distance of which was strikingly different from that which this rule would assign to it. "Kirkwood's Analogy," which gives the rotation-time of a planet when its time of revolution about the sun is known, likewise gives some striking coincidences, but our ignorance of the rotation-times of Mercury, Venus, Uranus, and Neptune, does not permit us to test it very closely.

It has long been a fascinating branch of inquiry to investigate the question of the existence of such laws, and several inquirers have worked assiduously at this question, in pretty much the same way in which Kepler worked at the discovery of his laws, i. e., by pure trial of various hypotheses. The volume before us contains the results of such work, and we propose to present, in brief, an analysis of these results. The volume opens with a statement of Kepler's laws, and with a table showing the values of the masses, mean distances, and densities which the author assumes as the bases of his discussion. We notice here, as elsewhere in the book, that such data are usually taken not from the original sources, but at second hand. With regard to the Masses as given by the author, we note that the mass of Neptune is *not* "the Poul-Kova deduction;" that the mass of Uranus should be credited to Struve; that Encke's mass of Mercury, which is adopted, is not of equal value with Le Verrier's, which has been published for many years.

In the second section the relations of the mean distances are considered: if of the distance of Neptune we take five-

ninths, and of the number thus obtained we again take five-ninths and so on, we thus form a geometrical series of numbers. Of the first eight of these numbers *four* express roughly the mean distances of Mars, Jupiter, Saturn, and Neptune (of course *this* distance is represented as it forms the starting-point of the process): *one* is roughly the distance of Mercury in *aphelion* (not its mean distance, which is the element of the problem, but its largest distance from the sun); *one* lies between Venus and the earth, *one* between Mars and Jupiter, and *one* between Uranus and Saturn, but much nearer Uranus. So far all is fact, and the candid observer arrived at this point might be supposed to say, With five-ninths as a ratio I can satisfy only *three* out of the *seven* conditions I seek to satisfy, and hence five-ninths is not the ratio I want. But at this point the author makes three assumptions: 1. The earth and Venus have the "characteristics of *half planets*." That is, one of them is on each side of one term of the author's utterly arbitrary geometrical series. 2. Uranus being on one side of another of these terms (although no planet is on the other side), it also will be considered as a "*half planet*." 3. Mercury has characteristics of a "*double planet*," because we are forced to consider it in its two positions, *aphelion* and *perihelion*, in order to make *it* agree with the above-mentioned arbitrary geometrical series. Now we have the basis for reducing these disorderly half, double, and missing planets, to something like order; for, putting nine-fifths (the reciprocal of $\frac{5}{9}$ths) equal to $r$, we have seen that the ratio $r$ does very well for Mars, Jupiter, Saturn, and Neptune (*whole* planets); by trial we can see that $r\,\frac{3}{4}$ does well for the "*exterior half planets*" (those *beyond* the terms of the primary series), and also that $r\,\frac{1}{2}$ will serve for Venus, an "*interior half planet*," "the only existing example of its kind in the planetary system."

These are the principal conclusions of the first two sections of the work: with a given ratio $\frac{5}{9}$ths we have satisfied *three* terms out of *seven*, and to reduce the four remaining terms to order we have made *three* arbitrary assumptions. The author now proposes *as a test* to use the mean distance of the asteroid-ring between Mars and Jupiter according to his primitive series. The terms for Saturn, Jupiter, and Mars, are known, and that for the asteroids can be put in by a simple proportion. He finds by this process that the ratio $r$ ($=\frac{9}{5}$ths) will satisfy the existing numbers better if we gradually decrease it as we go farther from the sun, and therefore this $r$, which at first was constant, is made variable, and the law of its variability is determined from four terms (Mars, Jupiter, Saturn, and asteroids) the value of one of which (the mean distance of the asteroid-ring) must long remain unknown; and in this way a "criterion" is set up. After this it is impossible to speak of this part of the book as a work of science; it is rather an exhibition of fancy. Tennyson has called the profession of the law "a multitude of single instances;" and, without passing the limits of decorum or truth, we may characterize the steps by which these final laws are reached in the same way. After all this adjustment of values, the mean distance of Uranus as represented by theory is in error by $\frac{1}{60}$ of its entire amount—a trifle of 7,000,000 miles. A foot-note here says, "Why, after all, Uranus seems to have, as it were, *fallen in* from his appropriate position, may be considered in another connection."

The satellite systems of Jupiter and Saturn are next considered, and similar laws are found to obtain; except that $r$, which for the planetary system was altered only into $r\,\frac{3}{4}$ and $r\,\frac{1}{2}$, here must become $r\,\frac{1}{2}$, $r\frac{6}{7}$, $r\,\frac{1}{4}$, $r\,\frac{5}{6}$, while for Uranus's satellites $r$ becomes $r\,\frac{2}{3}$. Moreover, while in the planetary system $r$ regularly *increased* from Neptune inward, in the system of Jupiter it *decreases* and in that of Saturn it is *constant*.

It seems hardly surprising that, with so much liberty of assumption, *any* set of conditions can be approximately fulfilled, and it is well to remember that, even if a much better fulfillment of these conditions could be made, it would not show that a physical law existed. This fallacy underlies the whole book.

Section 3 is devoted to "Theoretical Considerations," and here we will not follow the author, since what we have just examined is there assumed as fact.

The author's theory of the Zodiacal light is given at some length, and the book

closes with a "Summation of Coincidences" sixty-one in number, which are supposed to support the author's position. From what has been said it will be evident that we doubt the willingness of a cautious person to follow the author in his conclusions; and we must regret that the Smithsonian Institution has given this book the sanction of its high name as a "contribution to knowledge."

Geological Survey of Alabama. Report of Progress for 1874. By Eugene A. Smith, Ph. D., State Geologist.

This Report is the first of a series promised, giving in detail the geology of the State, to be followed by a general summary, with maps, charts, and illustrations. The final report will comprise the physical geography, geology, and paleontology, economic geology, agricultural relations, botany, and zoölogy, and will inaugurate a new era in the industrial progress and development of that State.

In the present Report several counties are considered separately, giving their topography, geology, and mineral resources, with a chemical report, and appendix of altitudes, mining statistics, etc. The Report of Prof. Smith is excellent in matter and method.

Catalogue of the Fishes of the East Coast of North America. By Theodore Gill, M. D., Ph. D.

This is one of the invaluable series of publications issued by the Smithsonian Institution, and is a revision of the catalogue prepared by the author in 1861. In that catalogue the number of species of fishes on our coast, from Greenland to Georgia, was given as 394, but accompanied by the remark that the number might be reduced by further observation. That has been done, and only 351 nominal species are enumerated in this catalogue, notwithstanding fifty species have been added since then.

Our vast extent of coast is divided in the catalogue into geographical areas, with boundaries more or less perfectly defined by the fauna characteristic of each. Thus the Arctic Fauna or realm is confined to the Arctic and Greenland seas. The next in order is called the Syrtensian Fauna, including the coasts of Labrador and Newfoundland. The Acadian Fauna extends thence to Cape Cod, but more southerly in deep water. The Virginian Fauna extends from Cape Cod to Cape Hatteras, and the Carolinian Fauna extends thence to the reefs of Florida.

Prof. Gill has done eminent service in recognizing the great public want of popular names to species of fishes. Throughout the catalogue popular or common names are appended to the scientific ones, and, in many cases, new names have been framed for species having no other distinctive ones. At the close of the catalogue is a very full bibliography of "East Coast Fishes," also an index to the catalogue of both scientific and popular names.

A Manual of Diet in Health and Disease. By Thomas King Chambers, M. D., Oxon. 310 pages, 8vo. Philadelphia: Henry C. Lea, 1875. Price, $2.75.

The aims of this hand-book are purely practical, and therefore it has not been encumbered by the addition of the chemical, botanical, and industrial learning which collects round every article interesting as an eatable. Space has been thus gained for a full discussion of many matters connecting food and drink with the daily current of social life, which the position of the author, as a practising physician, has led him to believe highly important to the present and future of our race. The book is divided into three parts. Part I., "General Dietetics," treats of "Theories of Dietetics;" "On the Choice of Food;" "On the Preparation of Food;" "On Digestion," and "Nutrition." Part II., "Special Dietetics of Health," treats of the "Regimen of Infancy and Motherhood;" "Childhood and Youth;" "Commercial Life;" "Literary and Professional Life;" "Noxious Trades;" "Athletic Training;" "Hints for Healthy Travelers;" "Effects of Climate;" "Starvation, Poverty, and Fasting;" "The Decline of Life;" and "Alcohol." Part III., "Dietetics in Sickness," comprises "Dietetics and Regimen of Acute Fevers;" "Dietetics and Regimen of Certain other Inflammatory States;" "Of Weak Digestion;" "Gout and Rheumatism;" "Gravel, Stone, Albuminuria, and Diabetes;" "Deficient Evacuation;" "Nerve

Disorders;" "Scrofula, Rickets, and Consumption;" "Disease of Heart and Arteries." It is written in the author's usual pointed style, and will prove serviceable alike to the profession and to people of common-sense.

Archæological Researches in Kentucky and Indiana, 1874. By F. W. Putnam.

This paper, which was read by Dr. Putnam before the Boston Society of Natural History, and printed in its proceedings, is a very interesting statement of what the author discovered in the mounds and caves of Kentucky and Indiana during the last season, also of early discoveries in the mammoth and other caves many years ago. He visited the spot in "Short Cave" where the famous "Mammoth Cave mummy" was found sixty years ago, and quotes a very full description of the mummy, written probably by Mr. Merriam, of Brooklyn, New York. The paper is an important contribution to archæological knowledge.

Practical Guide to the Determination of Minerals by the Blow-pipe. By Dr. C. W. C. Fuchs, Professor in the University of Heidelberg. Translated and edited by T. W. Danby, F. G. S. London: Field & Tuer. Price, $2.50.

The author informs us that the manuscript of this work has long been used by members of his own classes, and is now offered as an introduction to the determination of minerals by the blow-pipe process, and of crystallized specimens by their physical characteristics.

The work will be appreciated by students in the laboratory. It is of no value to the general reader.

Devonian Trilobites and Mollusks of Ereré, Province of Pará, Brazil. By Profs. Ch. Frederick Hartt and Richard Rathbun.

This paper, reprinted from the "Annals of the Lyceum of Natural History," New York, shows that a close relationship exists between the Devonian fossils found in New York State, and especially in the Hamilton rocks, and those of Erreré, in Brazil, the geological horizon, and many of the forms of life, being almost identical. Aside from the general scientific interest of the paper, these facts render it especially valuable.

Eighth Annual Report of the Peabody Museum of American Archæology and Ethnology. Presented to the President and Fellows of Harvard College. Cambridge, 1875.

This Report opens with appreciative recognition of the services of the late Prof. Jeffries Wyman, to whose industry and great abilities as an osteologist the successful organization of this museum is largely due. He was appointed curator at the first meeting of the Board of Trustees held after Mr. Peabody's "letter of gift," dated October 8, 1866, and in his first "Annual Report" stated that the collection consisted of about fifty specimens. The latest entries in the catalogue bring the numbers up to about 8,000.

The Report, which is illustrated, comprises the additions to the museum in 1874. Of these are varieties of jars, dishes, pots, drinking-cups, water-jugs, water-coolers, and statuettes, exceedingly curious and interesting. With ample resources and skillful management, the museum is a gratifying success.

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## PUBLICATIONS RECEIVED.

European Lighthouse Systems. By Major G. H. Elliot. New York: Van Nostrand. Pp. 284. Price, $5.

Notes on Building Construction. Philadelphia: Lippincott. Pp. 234.

Report of the Michigan State Board of Health. 1874. Pp. 221.

American State Universities and the University of Michigan. By Andrew Ten Brook. Cincinnati: Robert Clarke & Co. Pp. 418. Price, $3.50.

Algebraic Problems. By J. Ficklin, Ph. D. New York: Ivison, Blakeman, Taylor & Co. Pp. 192. Price, $1.50.

Religion and Science. By Charles W. Shields, D. D. New York: Scribner. Pp. 69. Price, $1.

What and How to Read. By G. A. F. Van Rhyn. New York: Appletons. Pp. 251.

Bacon *vs.* Shakespeare. By Thomas D. King. Montreal: Lovell Publishing Company. Pp. 187.

Startling Facts in Modern Spiritualism.

By N. B. Wolfe, M. D. Chicago: Religio-philosophical Publishing House. Pp. 570.

Missouri University Report, 1875. Pp. 210.

Report on the Mineralogy of Pennsylvania. By F. A. Genth. Pp. 206.

The Physiological Reasons why. By A. Hutchins, M. D. Brooklyn: W. W. Swayne. Pp. 50.

The Genera Geomys and Thomomys. By Dr. E. Coues. Pp. 73.

Bulletin of the Buffalo Society of Natural Science. Vol. II., No. 4.

Mineral Deposits in Essex County, Mass. By C. J. Brockway. Boston: A. Williams & Co. Pp. 60. Price, 50 cents.

Fishes of Indiana. By D. S. Jordan, M. D. Pp. 42.

Reasons for embracing the Doctrines of Swedenborg. By Rev. G. Bush. New York: E. H. Swinney. Pp. 120.

Transactions of the American Society of Civil Engineers. May, 1875. Pp. 140.

Bureau of Education. Nos. 3 and 4, 1875. Pp. 108.

Melanosiderite. By J. P. Cooke, Jr. Pp. 11.

The Sun and the Earth, by Balfour Stewart; Force, by J. W. Phelps. Boston: Estes & Lauriat. Pp. 31. Price, 25 cents.

Insects of the Field. By E. S. Packard, Jr. Boston: Estes & Lauriat. Pp. 31. Price, 25 cents.

## MISCELLANY.

### TO HERBERT SPENCER.

BY GRANT ALLEN.[1]

Deepest and mightiest of our later seers,
  Spencer, whose piercing glance descried afar
Down fathomless abysses of dead years
  The formless waste drift into sea or star,
And through vast wilds of elemental strife
Tracked out the first faint steps of yet unconscious life;

Thy hand has led us through the pathless maze,
  Chaotic sights and sounds that throng our brain,
Traced every strand along its tangled ways;
  And woven anew the many-colored skein;
Bound fact to fact in unrelenting laws,
And shown through minds and worlds the unity of cause.

Ere thou hadst read the universal plan,
  Our life was unto us a thing alone:
On this side Nature stood, on that side man,
  Irreconcilable, as twain, not one:
Thy voice first told us man was Nature's child,
And in one common law proclaimed them reconciled.

No partial system could suffice for thee,
  Whose eye has scanned the boundless realms of space;
Gazed, through the æons, on the fiery sea,
  And caught faint glimpses of that awful face,
Which, clad with earth, and heaven, and souls of men,
Veils its mysterious shape forever from our ken!

As tiny builders in some coral shoal,
  Raising the future mountain to the sky,
Build each his cell, unconscious of the whole,
  Live each his little life, and work and die;
Even so the lesser toilers in thy field
Build each the little pile his narrower range can yield.

But, like a skillful architect, thy mind
  Works up the rock those insect reasons frame,
With conscious plan and purpose clear defined
  In arch and column, toward a single aim,
Till, joining part to part, thy wider soul
Piles up a stately fane, a grand, consistent whole.

Not without honor is the prophet's name,
  Save with his country and his kin in time;
But after-years shall noise abroad thy fame
  Above all other fame in prose or rhyme;
For praise is his who builds for his own age,
But he who builds for time must look to time for wage.

Yet, though thy purer spirit do not need
  The vulgar guerdon of a brief renown,
Some little meed, at least, some little meed
  Our age may add to thy more lasting crown;
Accept an unknown singer's thanks for light
Cast on the dim abyss that bounds our little sight.

[1] Professor of Mental Philosophy in Queen's College, Jamaica.

**Sleep and Digestion.**—Speaking from his own experience, which would appear to differ from the experience of other people, Frank Buckland asserts that the best time to go to bed is immediately, or very soon, after the principal meal of the day. "All animals," he remarks, "always go to sleep, if they are not disturbed, after eating. This is especially noticeable in dogs; and the great John Hunter showed by an experiment that digestion goes on during sleep more than when an animal is awake and going about." Mr. Buckland finds a con-

firmation of his theory in the drowsiness which settles down on elderly men over their wine. "Nature says to them, 'Go to bed.' They will not go to bed, but still Nature will not allow her law to be broken, so she sends them to sleep sitting in their chairs." But, then, does not Nature quite as clearly indicate, by means of the nightmares and the unrest with which she torments the would-be sleeper who has gone to bed directly after a heavy meal, that a full stomach is not the best preparation for slumber? Many persons with whom this prescription for sleep would fail, may perhaps find another prescription given by Mr. Buckland more effectual, viz., eating onions, the essential oil of which possesses highly-soporific powers.

**The Use of Paris-Green.**—The use of Paris-green in dealing with the Colorado beetle has been condemned on the ground both that it poisons the soil, rendering it sterile, and that it is liable to be absorbed by the plant. Certain experiments made by Mr. McMurtrie, chemist of the Department of Agriculture, throw much light upon this question, and therefore are worthy of reproduction here. To determine the first point, that is, whether the Paris-green poisons the soil, Mr. McMurtrie planted peas in a number of flower-pots, each containing the same amount of earth, and all but one containing a certain proportion of Paris-green. The proportion of this substance varied from 100 milligrammes up to five grammes. The first five pots contained Paris-green as follows: No. 1, none; No. 2, 100 milligr.; No. 3, 200; No. 4, 300; No. 5, 400. In all of these the peas grew equally. In No. 6, containing 500 milligrammes, the plant was less vigorous than in No. 5. This, then, may be regarded as the proportion of Paris-green which impairs the fertility of soil. As the proportion increases, the plant grows feebler and feebler till No. 12 is reached, containing two grammes of Paris-green. Here the plant barely appears above the surface. In the rest of the pots, containing respectively three, four, and five grammes, the plant sends no shoot above the surface.

The proportion of 500 milligrammes in the flower-pot No. 6 is equal to 145.6 grammes per cubic foot, or 906.4 pounds per acre, calculating for a depth of one foot. Now, as less than two lbs. of Paris-green per acre is enough to use in warring against the beetle, it would take about 500 years to poison the soil, supposing the green to be applied every year, and that it was all retained. "But when rotation of crops is practised," says Mr. McMurtrie, "and application of the poison cannot therefore take place upon the same plot more than once in three or four years, it is probable that each application, being acted on by the natural solvents of the soil, will be removed by drainage before another is made." To the question whether arsenic can be absorbed and assimilated by the plant in the economy of growth, he replies in the negative. All of the plants grown, from the largest to the smallest, were examined according to Marsh's test for arsenic, but its presence could not be detected.

**Periodicity of Thunder-storms.**—W. von Bezold lately presented to the Munich Academy of Science a paper on the "Periodicity of Thunder-storms," basing his remarks upon a series of observations which extended over a period of 105 years prior to 1869. A synopsis of this paper we here reproduce from the *American Journal of Science.* He finds that in years when the temperature is high and the sun's surface relatively free from spots, thunder-storms are abundant. But as the maxima of the sun-spots coincide with the greatest intensity of auroral displays, it follows that both groups of phenomena, thunder-storms and auroras, to a certain extent supplement each other, so that years of frequent storms correspond to these auroras, and *vice versa.* He observes that such a connection between sun-spots and storms does not by any means sanction the supposition of a direct electrical interaction between the earth and the sun, but may be simply a consequence of a degree of insolation dependent upon the sun-spots.

These changes in the insolation, according to Köppen, manifest themselves in different latitudes not contemporaneously but successively. The phenomena of thunder-storms, on the other hand, do not depend alone upon the condition of the place in question with respect to temperature, but also on the condition of the atmosphere at

points far distant and belonging to another zone. This appears most distinctly in the storms which accompany electrical displays. The peculiar intermediate position which the weather curve takes between the curves of sun-spots and temperature may possibly find its explanation in this fact. Observations recently published in Saxony confirm these conclusions in a striking manner.

**Volcanic Outbreaks in Iceland.**—Since the beginning of the present year volcanic action has been almost incessant in Iceland. The following particulars of the outbreaks we find in *Nature:* In March the Dyngjufjöll was incessantly vomiting fire, and the eruption was steadily spreading over the wilderness. The farmers in the region around the My-vatn Mountains were obliged to remove in order to find pasture for their stock, the country being covered with ashes. Early in April a new eruption had broken out in a southeasterly direction from Barfell. A party went out from Laxardal to explore, and on approaching the place of eruption they found the fire rising up from three lava-craters. At a distance of 100 to 150 yards to the west from the craters a large fissure had formed itself as the fire broke out, and the land had sunk in to the depth of about 18 feet. Into the hollow thus formed the lava had poured at first, but now it flowed in a southwest direction from the two southern craters. The northernmost crater had the appearance of being oblong, about 600 yards in length, and from this crater the molten red-hot lava was thrown about 200 or 300 feet into the air in one compact column. The top of this column then assumed a palmated appearance, and the lava fell down in small particles, like drops from a jet of water, which, as they became separated from the column, grew gradually darker, and split into many pieces, bursting into lesser and lesser fragments as they cooled. No flames were observed, but the glare proceeded from these columns and the seething lava in the craters. At times the explorers could count twenty to thirty of these columns. No real smoke accompanied the eruption, but a bluish stream, which expanded and whitened in color as it rose to a greater distance from the crater; and such seemed to be the power of this blue jet of steam that it rose straight into the air for many thousand feet, despite a heavy wind blowing.

**How we keep our Mouths shut.**—Donders asserts that the mouth is kept closed, not by the action of the muscles connected with the lower jaw, but by atmospheric pressure. He has investigated this phenomenon experimentally. By employing a manometer, communicating with the space between the tongue and the hard palate, he finds, when the mouth is kept shut, a negative pressure corresponding to from two to four millimetres of the mercurial column. There are two suctorial spaces in the mouth: the principal one is bounded by the tongue below, the hard palate above, and the soft palate behind; the other is situated between the tongue and the floor of the mouth. The former is used in sucking liquid through a straw; the latter (sometimes) in smoking. Both are employed when we endeavor, with the mouth closed, to extract a foreign body from between the teeth. The mouth may be shut during sleep, when the muscles of mastication are relaxed. If a man fall asleep in the sitting posture with his mouth open, his jaw drops; the tongue not being in contact with the hard palate, the suctorial space is obliterated; the soft palate no longer adheres to the root of the tongue; and, if respiration be carried on through the mouth, the muscular curtain begins to vibrate, and snoring is the result.

**Aliaskan and Aleutian Mummies.**—The custom of preserving or mummifying the bodies of the dead, as formerly practised by the natives of the islands in Behring Sea, is accounted for very ingeniously by Mr. William H. Dall, in the *American Naturalist*. On the main-land, either on the Asiatic or the American side, the custom does not appear ever to have existed. In the Chukchee Peninsula, on the Asiatic side, there is no soil in which to bury the dead, and cremation is impossible from the want of wood; hence the natives expose their dead to the tender mercies of bears, dogs, and foxes. In the Yukon Valley, Alaska, the soil is frozen hard, and excavation is extremely difficult; but timber abounds,

and the bodies of the dead are boxed up in wooden coffins and elevated on four posts. On the islands the soil is not permanently frozen, and graves might be easily dug, but wood is scarce. Here the bodies might easily be buried, were it desirable. But, then, why *bury* the dead, if there are no wild animals to disturb the remains? The islands have no such animals, and hence the natives laid their dead away in nooks and crannies of the rocks.

Mr. Dall describes as follows the method adopted by the Kaniags and Aleüts in preserving dead bodies: First, an opening was made in the pelvic region, and the internal organs removed. The cavity was then filled with dry grass, and the body placed in running water. This in a short time removed most of the fatty portions, leaving only the skin, bones, and muscles. The knees were then brought up to the chin, and the whole body secured as compactly as possible by cords. The bones of the arms were sometimes broken to facilitate the process of compression. The remains were then dried. When thoroughly dried, the cords were removed, and the body usually wrapped in a shirt made of the skin of aquatic birds, with the feathers on; over this were wrapped pieces of matting, varying from coarse to exceedingly fine. Over this sometimes a water-proof material, made from the split intestines of the sea-lion, sewed together, was placed. Outside of this were usually the skins of the sea-otter, or other fur-animals, and the whole was secured in a case of seal-skins, coarse matting, or similar material, secured firmly by cords, and so arranged as to be capable of suspension.

**Age of the Niagara Gorge.**—It has for thirty years been the received opinion of geologists that the whole of the gorge of the Niagara, from Queenstown to the Falls, was excavated since the glacial period, and the work here done has been assumed to be a more or less accurate measure of the time elapsed since that period. But Mr. Thomas Belt, on a visit to Niagara last year, discovered what he takes to be sufficient evidence for asserting that the post glacial gorge extends only from Queenstown up to the whirlpool, and that between the latter point and the Falls the Niagara flows in its preglacial bed. The author holds that the present river is cutting back the gorge much more slowly than Lyell estimated; that, instead of one foot yearly, the retrocession is not more than, if it is as much as, one foot in ten years; and that, allowing for the comparative softness of the rocks below the whirlpool, we must put back the occurrence of the glacial period to at least 200,000 years ago, supposing the entire gorge from Queenstown to the Falls to have been excavated since that time. "But if," says Mr. Belt, "the conclusion at which I have arrived is correct — that the gorge, from the whirlpool to the Falls, is preglacial, and that the present river has only cut through the softer beds between Queenstown and the whirlpool, and above the latter point merely cleared out the preglacial gorge in the harder rocks—then 20,000 years, or even less, is amply sufficient for the work done, and the occurrence of the glacial epoch, as so measured, will be brought within the shorter period that, from other considerations I have argued, has elapsed since it was at its height."

**Have Animals a Sense of Humor?**—A writer in *Nature*, George J. Romanes, brings together some instances tending to show the existence in some animals of a sense of humor. A young orang-outang in the London Zoölogical Gardens used frequently to amuse the spectators by inverting on her head her feeding-tin, and the animal was evidently gratified when her conduct called forth a laugh. A Skye terrier belonging to Mr. Romanes, "while lying upon one side and violently grinning, would hold one leg in his mouth." The animal was much pleased whenever this "joke" was duly appreciated, but would become sulky if no notice was taken of it. This dog was fond of catching flies upon the window-panes; but, if ridiculed when unsuccessful, he was evidently much annoyed. Having failed repeatedly on a certain occasion to catch a fly, he eventually became so distressed that "he positively *pretended* to catch the fly, going through all the appropriate actions with lips and tongue, and afterward rubbing the ground with his neck as if to kill the victim. So well," continues Mr. Romanes, "was the whole process simu-

lated, that I should have been quite deceived, had I not seen that the fly was still upon the window. Accordingly I drew his attention to this fact, as well as to the absence of any thing upon the floor; and, when he saw that his hypocrisy had been detected, he slunk away under some furniture, evidently very much ashamed of himself."

**Mechanical Action of Light.**—It has been supposed that the rays of light, as distinguished from heat-rays, can produce no mechanical effects, such as repulsion and attraction; and the circumstance that these rays are unable to propel the arms of a vane suspended *in vacuo* has even been employed as an argument against the truth of Newton's emission theory of light. Mr. William Crookes, however, at a recent meeting of the London Royal Society, exhibited an apparatus which he calls "the radiometer," by means of which he proves that the luminous rays produce direct mechanical effects, after all the thermic rays have been strained out. The radiometer is described as consisting of four pith disks, fixed at the extremities of two crossed arms of straw balanced on a pivot at the point where the straws cross each other, so that they can spin round on the pivot. These pith disks are white on one of their sides and blackened on the other. The entire arrangement is inclosed in a glass bulb, from which the air is removed by means of a Sprengel pump. On being subjected to the action of light from which ninety-five per cent. of the heating rays had been strained out by means of an interposed plate of alum, the disks rotated with a speed little inferior to that when the heat-rays were allowed to mingle with the rays of light. And what is very singular, it is the blackened surface which is repelled by the luminous rays. Inasmuch as light is reflected by a white surface, and absorbed by a black, one should expect that in the experiment the white faces of the disks would rather be repelled. This anomaly Mr. Crookes does not attempt to account for, and he is content to let the facts speak for themselves, being confident that in due time the laws governing them will be made manifest.

It having been suggested by Prof. Osborne Reynolds that the movement of the little vane might be due to evaporation and condensation on the surface of the pith disks, Mr. Crookes showed that this was not the case. He exhibited the very same effects with a lever-arm of platinum, suspended by an arm of platinum, the whole of which had been heated to redness again and again, during thirty-six hours of exhaustion by the Sprengel pump.

**Prof. Huxley on the Amphioxus.**—In a preliminary note upon the brain and skull of Amphioxus (the lancelet), Prof. Huxley shows that, although these organs are not fully differentiated in this animal, yet well-marked divisions of the nervous axis and spinal column exist which answer to the encephalon and cranium of the higher fishes. The homologies of the anterior pairs of nerves are worked out, and the skull is considered to be represented by the segments of the body which lie in front of the fifteenth, counting from before backward. The many points of resemblance in structure between the lancelet and the young form or larva of the lamprey (*petromyzon*) are insisted on, and it is suggested that Amphioxus should be regarded as the type of a new primary division of the class Pisces, to be called *Entomocrania*, as contrasted with all other known fishes, in which the primary cranial segmentation is lost, and for which the term *Holocrania* is proposed.

**What Savages think of Twins.**—In Africa, according to Dr. Robert Brown ("Races of Mankind"), the birth of twins is commonly regarded as an evil omen. No one, except the twins themselves and their nearest relatives, is allowed to enter the hut in which they first saw the light. The children are not allowed to play with other children, and even the utensils of the hut are not permitted to be used by any one else. The mother is not allowed to talk to any one not belonging to her own family. If the children both live till the end of the sixth year, it is supposed that Nature has accommodated herself to their existence, and they are thenceforth admitted to association with their fellows. Nor is this abomination of twin births restricted to

Africa. In the island of Bali, near Java, a woman who is so unfortunate as to bear twins is obliged, along with her husband, to live for a month at the sea-shore or among the tombs, until she is purified. The Khasias of Hindostan consider that to have twins assimilates the mother to the lower animals, and one of them is frequently put to death. An exactly similar belief prevails among some of the native tribes of Vancouver Island. Among the Ainos, one of the twins is always killed, and in Arebo, in Guinea, both the twins and the mother are put to death.

**Father Secchi on Solar Spots.**—In summing up the results of his observations on solar prominences and spots from April, 1871, the Roman astronomer, Father Secchi, states that since that date there has been a very marked diminution both in the number of groups of sun-spots and in their area—a result of the eleven-year period, the maximum having occurred about 1871. But he has observed the same diminution in the number of prominences: in 1871 the daily average was about fifteen, while now it is six or seven. In the same period the number of groups of sun-spots in each rotation has decreased from about twenty-five to eight, and the mean area has diminished to about one-fifth. Further, the prominences are now very rare near the poles. Secchi further remarks on the discordance between his results of 1852, showing a difference of temperature between the solar equator and poles, and those of Prof. Langley, and infers that there has been a change in the sun in this respect, consequent on the decrease of solar activity. He objects to Langley's method of moving his thermopile to different parts of the image instead of moving the telescope so as to bring the points of the image in succession on the thermopile, and thus to avoid differences of inclination to the axis of the lenses.

**Prof. Loomis on the Storms of the United States.**—This eminent meteorologist presents, in the July number of the *American Journal of Science*, his third paper on storms, founded on the weather-maps of the Signal-Service. He is now able to confirm what was stated in his previous papers in regard to the general progress, direction, and barometric phenomena of storms in the United States. These papers of Prof. Loomis are admirable in method, and of very great value. The general direction of the storms which traverse the United States is found to be a little north of east, but varies somewhat with the seasons. Thus, July storms are most southerly in their direction, being a little south of east, those of February being most northerly. Rarely, storms move for a time northward or southward.

By direction of a storm is meant the movement over the country of the whole storm, not the direction of the winds, and its progress varies greatly in rapidity. The average velocity during the past three years has been 26 miles per hour, the storms of August being slowest, those of February and March being most rapid. The storm of February 22, 1874, moved at the tremendous rate of 53.3 miles an hour, or 1,280 miles in a day.

It is also shown that the progress of storms is not uniform throughout the day, but has a uniform daily variation. The velocity is greater by 25 per cent. from 4.35 P. M. to 11 P. M. than during other portions of the day, and this is constant during each month of the year. The greatest velocity occurs at about 7 P. M. without apparent relation to the wind's velocity, or absolute temperature. "But," the professor observes, "it is the time when the temperature of the day is declining most rapidly." Now, this change of temperature has direct relation to those conditions which cause precipitation and extend the rain-area. By reference to a former paper of Prof. Loomis it will be seen that condensation in front of the storm-centre is one means by which a storm progresses. It is continually making up in its front where the air is vapor-laden, not in its rear where the air has been deprived of its vapor.

It will hardly admit of question that the velocity of a storm's forward motion is usually accompanied by an extension of the rain area in the direction in which the storm progresses. The average extent of this area in front of the storm-centre during three years is found to be 542 miles. Now, if this be increased 100 miles, the velocity

of the storm is also increased, and the reverse occurs when the area is diminished.

The general outline of a storm-area is an oval, the longest diameter of which is in direction of the storm's progress.

Around the centre of a storm are points or lines of equal barometric pressure, and the lines thus formed are called isobaric curves. These are, in shape, irregular oval, and the longer diameter may be, or may not be, in the direction of the storm's longer axis. The prevalent direction is a little north of northeast.

Prof. Loomis suggested in a former paper that intense and sudden cold arises from vertical movement or displacement of air, by which the warm air suddenly, in some cases almost instantly, rises, the cold air of the upper atmosphere displacing it by its descent. This conclusion is confirmed by recent observations. On the 15th of January, 1875, the thermometer at Denver indicated a fall of temperature of 48° in one hour, and, in another instance cited, the change was 36° in five minutes! It is significant that these sudden invasions of cold air appear first, as a rule, on the Rocky Mountains, or contiguous highlands. The presence of mountains seems to favor the development of cold, which would not be the case if the movement of the cold wave was an horizontal one from the arctic regions, as formerly supposed.

**Experiments on the Sense of Taste.**—In a communication to the London Physical Society on subjective sensations of taste, Dr. Stone called attention to two simple experiments, the first of which consists in applying a strong dilution of nitric acid to the root of the tongue by sucking it through a fine glass tube. If pure water be swallowed immediately after this, a sweet taste is produced. The author compared this effect to the complementary images seen in the eye after gazing at a powerfully illuminated body. He then adverted to the taste of the galvanic current. In the well-known experiment with pieces of zinc and silver, the zinc is actually dissolved in the saliva. But if one pole of a strong battery (ten Grove's cells in this case) be applied to the nape of the neck, and the other brought to the forehead, besides the flash of light, a strong taste is experienced of a metallic character. It disappears on breaking contact; and for this reason, as well as from the fact that the tongue is not in the direct line of circuit, and also that there is no substance in the saliva likely by decomposition to cause metallic deposition, it could hardly be referred to chemical action, but must result from direct stimulation of the sensory apparatus. Dr. Stone thought that a glimpse might thus be obtained of some correlation between the *modus operandi* of hearing and sight and that of taste. In the first case, a supplementary and automatic sensation, in the second the effect of a metallic solution, both entirely subjective, were excited without the presence of any sapid substance. The explanation may be that both classes of phenomena are due to molecular motion.

**Do "Thorough-breds" revert?**—The saying is a common one that domesticated animals tend continually to revert to the original or wild type, and do so revert if domesticating influences are withdrawn. At the Hartford meeting of the American Association for the Advancement of Science, W. H. Brewer, Professor of Agriculture in Yale Scientific School, called attention to this subject. He cites remarks made by an eminent scientist at a previous meeting as follows: "The hog has been greatly changed by domestication, and yet when left to himself he soon returns to the original type. During the late war *some of the most improved breeds* were turned loose and left to shift for themselves. *Three years after I found them possessing all the physical characters of the wild-boar of Europe.* He also stated that a similar fact had been observed with Durham cattle.

This statement, and all similar ones, Prof. Brewer sharply challenges. He refers to the confidence which owners and breeders of "thorough-breds" have in the permanence of acquired qualities; and says he has failed to find a single instance of reversion, nor has he found any one who knows of its having taken place. He suggests that the dogma (reversion) is used as an argument to sustain a certain scientific hypothesis. In order to ascertain the facts, Prof. Brewer has issued a circular containing the

following inquiries, and promises to give the results obtained at some future meeting of the association:

"1. Have you personally ever known any case where *thorough-bred* short-horn cattle, because of climate, poor feed, neglect, or any other cause, have become in character any thing else than short-horns—in other words, *where from any cause thorough-bred short-horns have degenerated into animals of any other breed or type?*

"2. Do you personally know of *thorough-bred* animals of any other breeds so changing or reverting?

"3. Have you ever heard of such a thing taking place, in the experience of other breeders, so well authenticated that you believe it to be a fact?"

The professor concludes his circular with the following remarks: "That *grade* animals often 'revert,' that curious freaks and 'sports' often attend violent crossing (and also that breeds *deteriorate* under bad management or bad conditions), are well enough known, but these facts do not affect the specific questions asked where *the blood is supposed to be kept strictly pure.*"

**Laborers' Homes.**—Dr. Stephen Smith, in an address to the New York Public Health and Dwelling Reform Associations, points out various methods of improving the homes of the laboring classes in this city. He holds that every family almost may own a house for itself, and instances the city of Philadelphia, where tenement-houses are unknown, and where the day-laborer may, and does, occupy a house which is, or is in process of becoming, his own property. In the city of New York, south of the Harlem River, it is impossible for the poor to build houses, unless there be such a reconstruction of the land as will diminish the cost of individual lots, and allow of a larger number of single houses to the acre. Dr. Smith favors the plan of single rows of dwellings fronting at both extremities upon streets. Blocks thus laid out would have no inclosed courts, the dwellings would be flushed with free currents of air on both sides, and a much larger number of people could be accommodated in the same area.

The system of building associations, such as exist in Philadelphia, is highly commended by Dr. Smith. The relation of the laborer to the building association is thus stated: "He borrows $1,000 in cash, agreeing to pay $1,200 and the interest; he stands charged with $1,200, paying $60 per annum: it would take twenty years to pay up $1,200. But at the end of the time, his share being worth $1,200, he stops paying, and the house is his own. In fact, however, he is a participant in the profits, the premium and the interest he pays going to reimburse himself, and it only takes in practice ten or twelve years to put him in absolute possession of his home." Dr. Smith's address is worthy the attention of all classes; it is published in full in the *Sanitarian* for July.

In London, too, there exist various associations whose object is to provide improved dwellings for the laboring classes. At the present time these associations own 7,558 improved dwellings, capable of containing a population of 36,078. The buildings have been erected at a cost of about $6,000,000, and the enterprise is an undoubted financial success. But regarded from the sanitary and moral point of view the results are still more satisfactory. That the moral well-being of the inhabitants is promoted by the enlarged provision made in the model lodging-houses for the decencies of life is self-evident. The sanitary advantages possessed by these dwellings will be seen from a comparison of their death-rate with the death-rate of England in general, of London, or of any district of London. "There is not one year," says the *Sanitary Record*, "in which the death-rate prevailing in the model lodging-houses is not much lower than in England, and in the country, city, and town districts with which it is brought into comparison. Take, for instance, the healthy year 1868; it shows a death-rate in the model lodging-houses of 15 per 1,000, the most favorable figure for any mixed population of male and female being 22—a difference of 7 per 1,000 in favor of the model dwellings." It is a very significant fact that whereas in 1874 the death-rate of children under ten in the general population of London was 48 per 1,000, in the lodging-houses it was only 24 per 1,000. And the saving of disease must be in the like proportion. But yet in these dwellings the population is

very dense, at least four times as dense as in the most thickly-peopled districts of London. Thus in the most populous district of the metropolis (Westminster) the population is 235 persons to the acre, while in the dwellings provided by the Metropolitan Association, including the large court-yards and gardens, the average is 1,140 to the acre: in one instance is is even as high as 1,620 to the acre.

**Rate of Growths of Corals.**—It is stated by Prof. Joseph Le Conte, in the *American Journal of Science*, for July, that the well-known branching or tree-coral (*Madrepora cervicornis*) increases in the length of its branches by growth about 3½ inches in a year. He came to this conclusion in the following manner:

At the Tortugas he found the prongs of this coral very near the surface, and all with their extremities at nearly the same level. All the prongs were dead for about the last three inches of their length, the lower limit of death appearing to be a perfectly horizontal plane. He ascertained that hundreds of acres were thus clipped, having the appearance of a clipped hedge, and he traced this result directly to a change of level of the ocean during each year. This change is about ten inches at Key West, owing to prevalent winds, the highest level being in September, the lowest in January. It is obvious that the branches of coral shoot upward with rise of water, and when near its greatest fall the new growth is destroyed. Lower down the corals are sufficiently beneath the surface to remain uninjured by the surface changes. The amount of dead coral indicates the growth, which is three inches for the growing period, or about 3½ inches for the entire year for the madrepore-stems in this region.

**Methods of Physical Culture.**—At a meeting of the alumni of Amherst College, Dr. Nathan Allen made some remarks upon physical culture, showing that by right it must form an essential part of a college curriculum. He instituted a comparison between boating and ball-playing on the one hand and gymnastics on the other, and said that while the former are calculated to awaken public interest on the subject of physical culture, and to improve the physical condition of great numbers, yet as a *means of health* they are not the best adapted for the scholar. They call into exercise chiefly certain muscles of the chest, the spine and the limbs, and when long continued produce an abnormal development of these particular muscles at the expense of other muscles. But health rather depends upon an harmonious development of the whole body. Then, too, the exercises of boating and ball-playing become at times so violent and protracted as to cause congestion in the vital organs, resulting in serious diseases and endangering life. Furthermore, these exercises can be carried on only by a few individuals, in pleasant weather and at particular seasons—circumstances which render them unsuitable to the student.

With gymnastics it is very different. These can be carried on daily and systematically by all, with little loss of time or risk of injury to person or to good morals. They can be so varied as to call into exercise every muscle of the body, and, if need be, strengthen the weak parts and repress those in excess. While they are calculated to improve the general health, by producing a well-balanced organization, they aim to bring all the physical forces of the system into the most favorable condition for study and mental improvement. They tend to bring about the greatest possible harmony of action in every part, especially between the physical and mental, so that the machinery of body and mind shall work to the best advantage.

**Distribution of Ferns in the South Pacific Islands.**—M. Eugène Fournier, from a study of the 259 species of ferns native to New Caledonia, whereof 86 are special to that region, and the rest common to it and other groups of islands in the Pacific and Indian Oceans, has been led to the conclusion that at one time New Caledonia and New Holland, as well as New Zealand, were united by means of Norfolk Island and other submerged islands. This hypothesis, he says, will explain the simultaneous presence, in countries with different climates at the present day, of species belonging to homogeneous groups, which the currents would not have been able to transport in

preference to others, and which, living in interior mountainous regions, are less exposed than littoral species to be drawn off by extraneous agents. As to the Mauritian Islands, it is very difficult to explain, by the fact of transport, the singular affinities connecting their flora with that of the oceanic isles. To suppose some lands to have disappeared between Madagascar and Australia is a bold hypothesis which will, perhaps, impose itself one day on science—above all, after the results attained by geologists, and recently expressed according to the special studies of Alphonse Milne-Edwards.

**The Prairie Gopher.**—Among the burrowing species belonging to the squirrel family, the prairie gopher (*Spermophilus Richardsoni*) holds prominent rank. Though one of the most abundant animals in our country, infesting hundreds of thousands of square miles of territory, almost to the exclusion of other mammalian forms, the prairie gopher has but lately received the honor of an adequate description. This service has been rendered by Dr. Elliott Coues in the pages of the *American Naturalist*. The habitat of the prairie gopher appears to extend from the Red River of the North to the Rocky Mountains, and from latitude 38° to 55°. So numerous are they in Dakota and Montana that, according to Dr. Coues, should certain portions of these Territories ever be settled, the little gophers will contend with the husbandman for the land more persistently and successfully than the Indians can hope to. The animal seems to be a modification of the chipmunk; in the language of Dr. Coues, "If we take a chipmunk and crop its ears down close, cut off about a third of its tail, give it a blunter muzzle, and make a little alteration in its fore feet so that it could dig better," we have a pretty good prairie gopher. The holes they dig are small, but many of them, like the burrows of the badgers, foxes, and prairie wolves, will admit a horse's hoof. In some regions so numerous are these holes that it is impossible to gallop a hundred yards except at the risk of life or limb.

It is not easy to determine what particular kind of ground the gophers most affect. "Passing over a sterile, cactus-ridden, alkali-laden waste," says Dr. Coues, "there would be so many that I would say, 'This suits them best;' in camp that very night, in some low grassy spot near water, there they would be, plentiful as ever." If the animals have any preference, it is a choice of the lighter and more easily-worked soils; and they seem to haunt especially the slight knolls of the prairie a few feet above the general level. One gopher to a hole is the universal rule, nor has the author ever seen any signs of a burrow being occupied by a pair.

The female brings forth in June, but the young are never seen outside of the burrow till July, when they are about two-thirds grown. The number of young produced at a birth is supposed to be about eight.

Dr. Coues is of the opinion that the gopher is torpid during most of the winter. The animal hoards up food, it is true, but not in sufficient quantity to suffice for so active a creature during an entire winter. The author has often watched them, where the grass was taller than usual, gathering their store. They rise straight up on their haunches, seize the grass-top, and bite it off; then settling down with a peculiar jerk, they sit with arched back, and stow away the provender in their pouches, with the aid of their fore-paws. Their cheek-pouches, both together, would hardly hold a heaping teaspoonful. Though properly a vegetarian, the gopher derives no small share of his summer food from carcasses of buffalo.

**Recovery from Lightning-Stroke.** — In his valuable work on "The Maintenance of Health," Dr. Fothergill has the following on resuscitation after lightning-stroke: "Persons struck by lightning are not always dead when they appear to be so. There are few recoveries from this state, because no means are tried to restore the sufferer. In the tropics there are many instances of persons, struck down by lightning, recovering after a heavy thunder-shower; and it would appear that cold affusion to the body has a decided action in such cases. The injured cannot be harmed by the free use of cold water, and if only an occasional recovery took place it would be well worth the pains bestowed. The persons so injured should have cold water poured or even dashed freely over them."

**The Air-Bladder of Fishes.**—While engaged in measuring a degree of the meridian in 1806, the eminent physicist and astronomer Biot accidentally made the discovery that fishes living at great depths have the air-bladder filled with almost pure oxygen. Another French scientist, Dr. Moreau, has recently confirmed and extended this observation of Biot's. According to Moreau, the air-bladder secretes pure oxygen, and the presence of other gases is due to other causes besides the secretion of the organ. To prove this point, he examined fishes which had for a considerable time lived in very shallow water, and found, from several analyses, that the average amount of oxygen in the air of their swimming-bladders was about sixteen per cent. He then plunged the fishes in water to the depth of about twenty-five feet, and found that the quantity of gas in the air-bladder was increased. The oxygen was now from forty-five to fifty-two per cent.

**New Fossil Ungulates from Mexico.**—In a communication to the Philadelphia Academy of Natural Sciences, Prof. Cope describes some new fossil Ungulata found by himself while employed in the Wheeler Topographical and Geological Survey of New Mexico. One of these fossil ungulates, *Pliauchenia Humphreysiana* (a new genus and species), is regarded as representing a genus of *Camelidæ* intermediary between *Procamelus occidentalis* and *Auchenia*. *P. Humphreysiana* was of about the same size as the former of these two animals, or somewhat larger than any of the existing llamas. Another new species of this same genus is *Pliauchenia vulcanorum*, represented in Prof. Cope's collection by the left maxillary bone, which proves it to have been a camel of about the size of the existing dromedary, and considerably larger than the preceding species. The typical specimen was found near Pojuaque, a village of the Pueblo Indians. Various bones of camels of the size of *P. vulcanorum* were also found, some of which doubtless belong to the same species. Of *Hippotherium calamarium*, a new species of three-toed horse, the oral and palatine parts of the skull, with the superior dental series of both sides, were found near San Ildefonso. Dr. Cope points out the specific differences between this animal and Leidy's *H. occidentale*, *H. speciosum*, and *H. gratum*. *Aphelops jemezanus*, a new species of fossil rhinoceros, is represented by a right mandibular ramus, found near the town of Santa Clara, on the west side of the Rio Grande.

**Parental Instinct in Fishes.**—The Trinidad perch does not stand all alone among the finny tribes in caring for the safety of its young. A correspondent, after reading the article "A Motherly Fish," on page 126 of the present volume, writes us as follows: "I think it is known to our fishermen that the catfish watches over its young. For the fact that it does I can vouch. A friend whose place of business was on the quiet wharf of Havre de Grace, Maryland, had an opportunity, during more than a week and several times each day, of observing the parental care of this fish. There were always two fishes with the brood. When approached, one of these would dart off, while the other, naturally supposed to be the mother, could be seen to flap her tail against the bottom till a cloud of mud was raised, concealing herself and her little ones. When the observer remained perfectly still for some time, the water becoming clear again, the mother could be seen hovering over a dark mass of moving small-fry a foot or more in diameter, while a little way off the other fish would be in attendance."

**Mouthless Fishes.**—Prof. Leidy lately exhibited at the Philadelphia Academy of Sciences an apparently mouthless fish, found in the Ouachita River, Arkansas. The fish is the buffalo sucker (*Catastomus bubalus*), an inhabitant of the Mississippi and its tributaries. The specimen is fifteen inches long. The maxillaries, premaxillaries, and mandible, are absent, and the integument is tightly extended between the end of the snout, the suborbitals, and the articular ends of the quadrates. In the centre of this expansion of the skin there is a small oval aperture one-fourth of an inch fore and aft, and one-eighth of an inch in transverse diameter. The hole is sufficient to admit a current of water for the purposes of respiration; but it is difficult to understand how the fish had procured its food. The cyprinoids generally are remarkable for

their small, toothless mouth, but it is nevertheless important in its prehensile capacity. The condition of the specimen is of course a deformity, but appears to be the result of a want of development of the jaws, and not of accidental violence. Such fishes are often caught in the Ouachita, and occasionally even they have been reported without a vestige of an oral orifice. If the latter condition really occurs, the fish can only supply itself with food and with water for respiration through the branchial fissures, by the alternating outward and inward movements of the opercula.

**Hatching Frogs under Colored Glass.**—In an experiment made by M. Thury, the eggs of *Rana temporaria*, a species of frog, were placed under identical favorable conditions, with the exception that some of the eggs received light through colorless glass, and others through green glass. The former developed rapidly, and by the end of May had a length of over one and a half inch, and well-developed hind-legs in most of them; the others were slowly developed, blackish in color, hardly had a length of three-quarters of an inch by the end of May, and were without a trace of hind-legs. By the 10th of June the former had their fore-legs, and some were changed to frogs; the others, still black, had no trace of legs, and breathed almost exclusively by means of their gills. By the 15th of July the one lot had become frogs; the others still had no legs, and by the 2d of August they were all dead, without a trace of legs having appeared. Some of the young of this lot, transferred to the vessel in which were contained the developed frogs, finished their metamorphosis.

**Equine Idiocy.**—A plant known in California as "rattle-weed" is said to produce in animals which eat of it symptoms much resembling those of amentia and frenzy. A correspondent of a San Francisco newspaper, writing from Monterey County, describes as follows the effect produced by this plant on a herd of fifty horses on a ranche in the southern part of that county: "They became," he says, "crazy, forsook the farm, and wandered off one by one over the plain, paying no attention to their mates or any thing else. They were too muddled in their brains to seek for water, and most of them died of thirst. Although they were wild, and had never been handled, any person could walk up to them on the plain and hit them with his hand, when they would jump, perhaps, straight up in the air, perhaps some other way, and act as though they were trying to leap a fence at every step. They seemed to retain their sight, yet would not turn aside for any thing. The poor demented beasts would walk over a precipice without the slightest fear or hesitation."

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# NOTES.

The Cincinnati Industrial Exposition of the present year includes a Department of Natural History and Antiquities, and prizes are offered for the best collections in geology, and mineralogy, conchology, zoölogy, botany, numismatology, and archæology. The managers promise that the greatest care will be taken of all specimens sent in for exhibition. The prizes consist of silver and bronze medals.

A novel form of snow-spectacles has been devised for the use of the British arctic expedition. These spectacles have neither glass nor iron in their composition; they are made of ebonite, and tied on the head by a velvet cord. They somewhat resemble two half walnut-shells fastened over the eye, and the wearer sees through a simple slit in front of the pupil. To give the wearer a side view, the sides of the eye-box are perforated with minute holes. These spectacles are said to be of great service in reading by lamp or gas light.

The Royal Agricultural Society of England has the most numerous membership of any similar association in the world. It has on its roll 5,846 names. Its "Transactions" are published in half-yearly volumes.

The *Phylloxera vastatrix* has made its appearance in England. At a meeting of the London Entomological Society, Mr. McLachlan exhibited a portion of a vine-leaf on which were the galls of *Phylloxera*. The leaf had been plucked in a greenhouse near London.

Bean's pneumatic-electric apparatus for lighting and extinguishing street-lamps is now in practical operation in a large part of the business portion of Providence, Rhode Island. The principle of this apparatus consists in a combination of compressed and rarefied air to open and close gas-cocks, and an electro-galvanic current, affording a spark to light the gas. It enables a single

operator at will to light or extinguish all the street-lamps of a city.

The "Khedival" Geographical Society of Cairo lately held its first meeting under the presidency of Dr. Schweinfurth. The Khedive gives to the society a local habitation, suitably furnished, and also subscribes 10,000 francs a year to its funds.

Three soldiers were simultaneously struck by lightning at the Satory Barracks, Paris, May 15th. In two of them the lightning produced complete relaxation of the muscles, and in the third muscular contraction. The latter, unlike the former, retained consciousness throughout. All recovered in a few days. The metallic buttons on their clothing were not affected by the electric current.

The silver-mining region of Massachusetts, we are informed by a writer in the *Engineering and Mining Journal*, appears to extend from Gloucester, Massachusetts, on the south, to Portsmouth, New Hampshire on the north, and from the Atlantic on the east to North Andover, Massachusetts, on the west. The first discovered and thus far most prominent lode is the "Chipman," at Newburyport, which has been traced some three miles. The ore of this lode is chiefly galena, carrying from 50 to 150 ounces of silver to the ton. The average thickness of vein-rock on the Chipman lode is about 60 feet.

A mill has been erected on the line of the Los Angeles & Independence Railroad, California, for the purpose of manufacturing the fibre of the cactus into paper-pulp. The experiment has been tried, says the *Scientific Press*, and an excellent quality of paper is the result.

The managers of the great aquarium at Brighton, England, were very heavily fined a month or two since for keeping open on Sunday. A religious fanatic brought to the notice of the courts the violation, by the directors of the Aquarium, of an obsolete statute "for preventing the abuse and profanation of the Lord's Day." In the mean time publicans are allowed to keep their places open on the "Lord's Day."

In the *American Journal of Sciences* for May, Prof. James D. Dana examines the evidences of the contemporaneity of man and the mastodon in Missouri, as presented in various pamphlets issued by Albert Koch, of St. Louis. Prof. Dana shows conclusively that Koch's "evidences" are worthless.

In consequence of the excessive cold of the past winter, the deaths registered in the eight principal towns of Scotland in December amounted to 3,906, or, taking into account the increase of population, 1,000 in excess of the preceding month, and nearly 700 more than in any month since 1855, when registration of deaths commenced. The mortality in France from the same cause was equally great.

Fayette County, Tennessee, is said, in the Report of the Department of Agriculture, to have suffered a very great loss of mules and horses last spring by the buffalo-gnat. The best remedy against these pests is to put the stock at once in a dark stable, to be kept filled with smoke. "Death," says the report, "doubtless is partly caused by loss of blood, but mainly by poisoning the circulation."

In our sixth volume, p. 743, Dr. Abbott confirms Wilson's statement as to the outside lichen covering of the yellow-bird's nest. A correspondent, writing from Southern Minnesota, confirms Brewer's statement, viz., that this bird covers the outside of its nest with fine vegetable fibres. The fibre commonly used is hemp. The yellow-bird thus appears to construct its nest differently in the West from what it does in the East. As for the eggs, our correspondent says that all he has ever seen have been marked with brown splotches on the large end, and he has some specimens which are thickly spotted over the entire surface.

The annual death-rate of various cities in the United States, for four weeks in April, as stated by the *Sanitarian*, shows a minimum (Toledo) of 11.04, and a maximum (Paterson) of 30.63. The rate in New York was 28.70, Philadelphia 24.42, St. Louis 12.65, Chicago 19.11, Boston 20.31, Baltimore 17.53, Cincinnati 15.15, New Orleans 21.09, San Francisco 17.71, Pittsburg 19.22, Charleston 27.82.

The Peabody Museum of Archæology and Ethnology at Cambridge, Massachusetts, as we learn from the *American Naturalist*, lately received from Mr. A. Agassiz a fine collection of objects illustrating the archæology and ethnology of Peru. The collection includes a large number of vases, several mummies, and trinkets, utensils, etc., from burial-grounds; also a number of human crania from the burial-towers near Lake Titicaca.

Sir William E. Logan, the geologist, recently deceased, was a native of Montreal, born in 1798. He received his early education in Edinburgh. His first geological researches were made in the coal-fields of South Wales. In 1841 he returned to Canada, and two years later was appointed chief of the geological survey of the provinces. He held this position till 1869, when age and infirmity compelled him to resign. "He has done," says Prof. Geikie, "a great work in his time, and has left a name and an example to be cherished among the honored possessions of geology."

G. G. Stokes

THE

# POPULAR SCIENCE MONTHLY.

**OCTOBER, 1875.**

## BATS AND THEIR YOUNG.

By Prof. BURT G. WILDER.

EXCEPTING the colder regions, all parts of the world are inhabited by bats. There are many kinds, and they often occur in very large numbers. Probably there are very few persons, young or old, who have not seen a bat. Yet, aside from professed naturalists, it is equally probable that there are still fewer who, from direct observation, could give any accurate description of their appearance or their habits, their structure, or their relations with the "birds of the air," or the "beasts of the earth," to both of which bats bear more or less resemblance.

Nor is this strange; for bats pass the day in caves and deserted buildings, and fly about in pursuit of prey only in the twilight. Much less rapid than that of birds, their flight is so irregular as to render it difficult to follow their course, and in the dusk they are often mistaken for somewhat eccentric members of the swallow family.

Their very aspect is repulsive; they often emit an unpleasant odor; and, worse than all, there is reason for believing them to serve as the vehicle by which the *Cimex lectularius*, that terror of housekeepers, has sometimes gained entrance to habitations where its presence would never have been suspected.

When taken they bite so fiercely that we may be thankful that they are no larger, and that, as a rule, they prefer insects to human beings as food. No tiger could be more violent in its demonstrations or more capable of using its only weapons, the sharp, almost needle-like eye-teeth.

This accounts for the rarity of instances of the domestication of bats, and this, in part, for the difficulty of making any extended observations upon them. Having found recorded but two such cases, I will begin my account of bats in general with a brief history of one individual which I succeeded in taming quite thoroughly. It was

when I was a boy, and the details have escaped me, but the main facts are as follows:

One of our common bats (probably either the "little brown bat," *Vespertilio subulatus*, or the "little red bat") flew into the house one evening and was caught under a hat. It squeaked and snapped its little jaws so viciously that all efforts toward closer acquaintance were postponed until morning.

When uncovered the next day it seemed as fierce as before, but less active in its movements, probably overpowered by the glare of daylight. When touched its jaws opened wide, the sharp teeth were

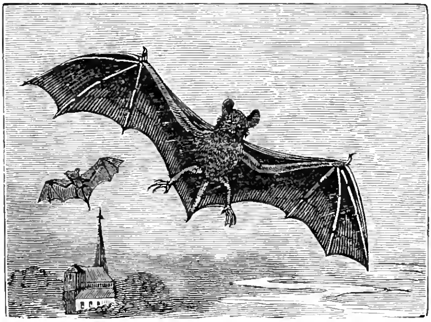


Fig. 1.—Common English Bat (*Vespertilio communis*).

exposed, and from its little throat came the sharp steely clicks so characteristic of our bats. Nor did this fierce demeanor soften in the least during the day, and when night approached I was about to let it go, but the sight of a big fly upon the window suggested an attempt to feed the captive. Held by the wings between the points of a pair of forceps, the fly had no sooner touched the bat's nose than it was seized, crunched, and swallowed. The rapidity of its disappearance accorded with the width to which the eater's jaws were opened to receive it, and, but for the dismal crackling of skin and wings, reminded one of the sudden engulfment of beetles by a hungry young robin.

A second fly went the same road. The third was more deliberately masticated, and I ventured to pat the devourer's head. Instantly all was changed. The jaws gaped as if they would separate, the crushed fly dropped from the tongue, and the well-known click proclaimed a hatred and defiance which hunger could not subdue nor food appease. So at least it seemed, and I think any but a boy-naturalist would have yielded to the temptation to fling the spiteful creature out of the window. Perhaps, too, a certain obstinacy made me unwilling to so easily relinquish the newly-formed hope of domesticating a bat. At any rate, another fly was presented, and, like the former, dropped the moment my fingers touched the head of the bat.

With a third I waited until the bat seemed to be actually swallowing, and unable to either discontinue that process or open its mouth to any extent.[1]

Its rage and perplexity were comical to behold, and, when the fly was really down, it seemed to almost burst with the effort to express its indignation. But this did not prevent it from falling into the same trap again; and, to make a long story short, it finally learned by experience that, while chewing and swallowing were more or less interrupted by snapping at me, both operations were quite compatible with my gentle stroking of its head. And even a bat has brains enough to see the foolishness of losing a dinner in order to resent an unsolicited kindness.

In a few days the bat would take flies from my fingers; although, either from eagerness or because blinded by the light, it too often nipped me sharply in its efforts to seize the victim.

Its voracity was almost incredible. For several weeks it devoured at least fifty house-flies in a day (it was vacation, and my playmates had to assist me), and once disposed of *eighty* between daybreak and sunset.

This bat I kept for more than two months. It would shuffle across the table when I entered the room, and lift up its head for the expected fly. When traveling it was carried in my breast-pocket.

In the fall it died, either from overeating or lack of exercise, for I dared not let it out-of-doors, and it was so apt to injure itself in the rooms that I seldom allowed it to fly.

I should add that it drank frequently and greedily from the tip of a camel's-hair pencil.

The following bits of bat biography are from White's "Natural History of Selborne," and the "Annals and Magazine of Natural History:"

"Having caught a lively male specimen of the common 'long-eared bat' (*Plecotus auritus*) and placed the little fellow in a wire-gauze cage, and inserted a few large flies, he was soon attracted by their buzz, and, pricking up his ears (just as a donkey does), he pounced upon his prey. But, instead of taking it directly into his mouth, he covered it with his body and beat it by aid of its arms, etc., into the bag formed by the interfemoral membrane. He then put his head under his body, withdrew the fly from the bag, and devoured it at leisure.

"This appeared to be always the *modus operandi*, more or less cleverly performed. Several times, when the fly happened to be on the flat surface of the ground, the capture appeared more difficult, and my little friend was, by his exertions, thrown on his back. The tail could

[1] I did not understand this at the time. If my readers will try it, they will find that it is very difficult to even begin to swallow with the mouth open, and almost impossible to prevent the morsel from descending after reaching the back of the throat.

then be seen turned round, with its tip and the margin of the membrane pressed against the stomach, forming a capital trap, holding the fly, the captor remaining on his back till he had withdrawn the fly from the bag.

"I had no opportunity of observing the action when the bat was in full flight; but, if the insect was captured a few inches from the side of the cage, the mode was the same! When flying, the interfemoral

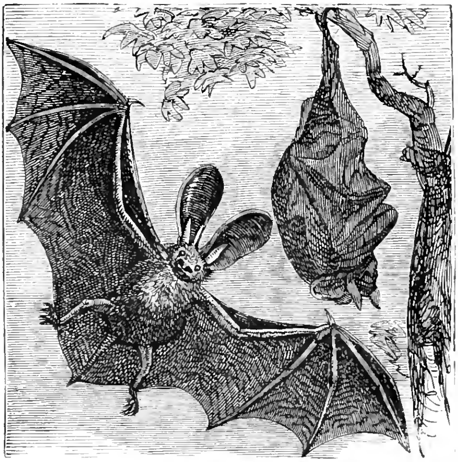


Fig. 2.—Long-eared English Bat (*Plecotus auritus*).

membrane is not extended to a flat surface (and appears not capable of being so stretched), but always preserves a more or less concave form, highly calculated to serve the purposes of a skim-net to capture insects on the wing.

"Occasionally, when the bat was sleepy, sitting at the bottom of the cage, nodding his head, a poor, silly 'blue-bottle fly,' no doubt of tender age, and not read in the natural history of the *Vespertilionidæ*, with the greatest confidence walked quietly under the bat, passing nose, ear, and eyes, without danger; but, immediately he touched the sensitive membrane of the bag, it was closed upon him, and there was no retreat except by being helped out of the difficulty by the teeth of the bat.

"I was much entertained last summer with a tame bat which would take flies out of a person's hand. If you gave it any thing to eat, it brought its wings round before the mouth, hovering and hiding its head in the manner of birds of prey when they feed. The adroitness it showed in shearing off the wings of the flies, which were always rejected, was worthy of observation, and pleased me much. Insects seemed to be most acceptable, though it did not refuse raw flesh when offered. . . . I saw it several times confute the vulgar opinion that

bats, when down on a flat surface, cannot get on the wing again, by rising with great ease from the floor. . . ."

So far, we have contented ourselves with treating of bats simply as such, and without reference to their internal structure, their relationship with other animals, or even their differences among themselves; much less have we approached the deeper questions of their origin and destiny—the probabilities as to their ancestry, and the possibilities as to their more or less remote descendants.

In the same way the astronomer may, for a time, speak of a comet only as a certain well-known celestial phenomenon, which may be as obvious to the unaided vision of the ignorant as to his own. But, sooner or later, he cannot refrain from discussing its chemical and physical condition, its course through space, its relations to other comets and to the stars, and, finally, its probable origin from nebulous matter, and its possible transformation into a world like our own.

The comparison may be carried one step farther. For, to the ignorant and superstitious the sudden apparition of a blazing comet has often been a portent of disaster, while even the intelligent shrink with aversion from the flitting bat, and make comparisons with evil spirits.

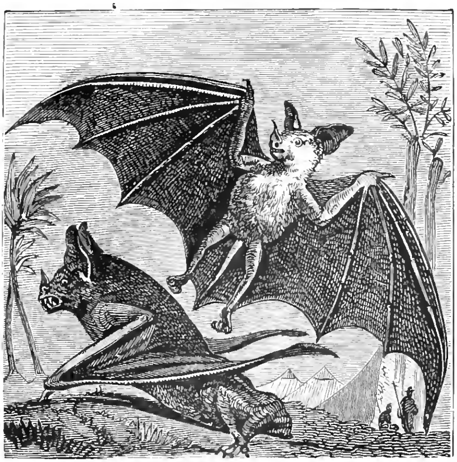


FIG. 3.—VAMPIRE-BAT OF SOUTH AMERICA (*Vampirus spectrum*).

It must be admitted that most bats are "uncanny" in their aspect, and unfriendly in disposition; while the legends of blood-thirsty vampires have only too much foundation in fact.

But it is only fair to them (the bat family) to admit that the number of species which thus injure men and the larger animals is very small; and that, while all of our own bats, and most of those of other lands, are fierce devourers of insects, and use their sharp teeth for defense against their captors, there are many kinds, especially the larger (Roussettes, etc.), which live almost wholly upon fruits, and are, more-

over, quite good eating themselves. So there should be made a distinction between them as between the venomous and the harmless serpents and the more and the less poisonous spiders.

Perhaps one element of distrust of the bat family arises from their apparent non-conformity to either of the common animal types. The bat seems to be either a bird with hair and teeth, bringing forth its young alive, or a mammal with wings, and the general aspect and habit of a bird. Add to these exceptional features that their attitude, when at rest, is always head downward, and that their legs are so turned outward as to bring the knees behind instead of in front, and we may almost pardon the common dislike of the whole family of bats.

Fig. 4.—Flying-Fox or Roussette (*Pteropus rubricollis*)

We may as well state at once that a bat is really a *mammal;* that is, it agrees with moles, rats, sheep, horses, cats, monkeys, and men, in bringing forth its young alive, and nursing them by milk; in having red blood-corpuscles, which contain no nucleus; in being clothed with hair; and in possessing a *corpus callosum*, that is, a band of fibres connecting the two cerebral hemispheres.

There are other anatomical features which link the bats closely with the moles and shrews and hedge-hogs. Indeed, the bat might be described as a flying mole, or the mole as a burrowing bat.

Twenty years ago one of these phrases might have been as acceptable as the other; for they would have implied only an ideal connection between the forms. But now, when the idea of an actual evolution or derivation of widely-different forms from one another, or from common stocks, is rapidly becoming the fundamental postulate of all biological research, we are bound to inquire whether one mode of expression is not much more likely to be true than the other.

For the solution of this, as of most such inquiries, we must appeal to embryology, to the study of the development of animals, and of the resemblances between the earlier stages of some and the later stages of others.

Our first object is to confirm the conclusion that bats are mammals rather than birds. And here, strangely enough, we find that the matter of *size*, usually regarded as of little moment in zoölogical discrimination, becomes of primary importance. All animals, mammals as well as birds, are formed from eggs. An egg, or ovum, is a cell with special endowments, and capable of availing itself of the peculiar conditions under which it is placed, the first of these conditions being the access of the zoösperms of the male. Now, the eggs of all mammals are small, usually microscopic. The human ovum is about $\frac{1}{120}$ of an inch in diameter.

Therefore, although the yolk or essential part of the egg of a humming-bird may be pretty small, it is far larger than the largest mammalian ovum; while that of the ostrich or the *Epyornis* is simply gigantic in comparison.

Now, I am not aware that the ovum of a bat has ever been examined, but there can be doubt of its minuteness as compared with that of any known bird. Fig. 5 shows, of its natural size, the earliest embryo of a bat I have ever heard of. Its length as it lies is much less than that of a humming-bird's egg. Moreover, since the young bird is developed upon the yolk, and the latter remains of considerable size until very near the period of hatching, and since the yolk of our little bat either has been already absorbed or is too minute for detection, it may be considered that it was much smaller than that of birds.

Finally, the simple fact that the little bat was taken out of the mother already somewhat advanced in development, is clear proof that it is not a bird.[1]

Aside from the absence of yolk, the form of the smallest embryo, above figured, might not determine its mammalian nature; but the remaining figures, however little some of them may resemble quadrupeds, are evidently not birds. The tail is too long (for any bird excepting the *Archeopteryx*); the muzzle is rounded, the feet have five divisions more or less marked, while no bird has more than four toes; and, although the hands may in some cases resemble a bird's wing, yet here too are five fingers, and the wing is evidently an expansion of the hand itself by the elongation and separation of the fingers, rather than a slender hand with feathers attached to the hinder border as with birds.

[1] There are no known birds which normally produce living young; but I have a chicken-like body nearly three inches long, which was developed within the hen. It was shown at the meeting of the American Association for the Advancement of Science, this year. Its exact nature can only be learned after full examination of the structure.

With the more advanced embryos the prominent ear would be conclusive against their avian nature, and the nostrils, where they show, are not those of birds.

We may, then, dismiss from our minds any anxiety as to whether bats are partly birds and partly mammals, and conclude merely that, upon the essential mammalian structure, there have been superinduced features which enable the bat to fly in the air; these, however, no more making it a bird than the form and habit of the whale and manatee render them fishes.

The second question is, whether bats are to be regarded as the progenitors or the descendants of the moles and shrews; or, to put it more accurately (since the idea of derivation does not imply that living species have descended from other living species, but from similar extinct species or from others which combined features since separated in the two forms), is it probable that the existing bats have been produced from original stocks more nearly resembling the moles or the reverse? That the former is the more probable, is indicated upon three grounds:

1. The bat form is peculiar among mammals, and does not, like the *Ornithorhynchus* and *Echidna*, manifest any *internal* structural affinity with birds. There is a much more marked resemblance to the extinct flying reptiles (*Pterodactyli*), but this is probably one of analogy.

2. The embryo bat resembles the ordinary small mammal; the long fingers, the persistence of the web between them, and its continuation from the border of the body and tail, are features of later appearance.

3. In one embryo (Fig. 9), the thinness and prolongation of the muzzle as compared with the lower jaw may be compared with the elongated snouts of the "star-nosed mole" and the "elephant shrew."

I have never had the opportunity of examining the young of moles or shrews. This would be very desirable, and, one would think, not difficult to accomplish.

Figs. 5 to 11 are intended chiefly to show the gradual development of the limbs, so the other parts are drawn with less detail, and no attempt is made to elucidate the manner of formation of the face from the visceral arches.

The series begins with Fig. 5. Here the body is simply an elongated mass, longer and rounded at the head end, and tapering at the other extremity. It is twisted upon itself, as is often the case with young embryos. The yolk-sack and membranes are not well preserved, and are not shown at all in the figure. This embryo may be regarded as quite small for even a bat. The limbs have not appeared, so the tail does not form a distinct prolongation. (The lower figure is of natural size; the upper is enlarged five diameters.)

In Fig. 6 the arm (*ar*) and leg (*pes*) project as little flat pads from the sides of the body. There is no sign of subdivision into fingers and toes, and very little difference between the two limbs. It is worth


FIG. 5.

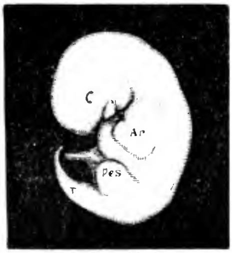



FIG. 6.

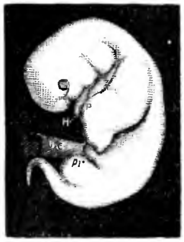



FIG. 7.

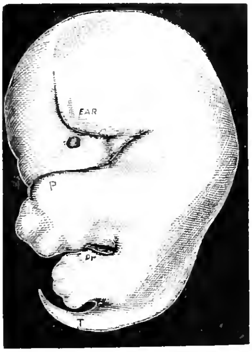



FIG. 8.


FIG. 9.

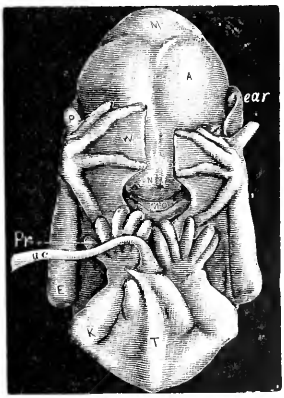



FIG. 10.


FIG. 11.

EMBRYO BATS. All, excepting Fig. 11, enlarged 5 diameters.

## *Explanation of Plate.*[1]

Figs. 10 and 11 from the little brown bat (*Vespertilio subulatus*), the others from a Brazilian species (*Nyctinomus Brasiliensis*); Fig. 11 and the smaller part of Fig. 5 are of natural size. All the others are enlarged 5 diameters; that is, 25 areas. The lettering is uniform, as follows: *u c*, umbilical cord; not seen in 5 or 8. *H*, head; *T*, tail; *Ar*, armus or anterior limb; *Pes*, foot; *P*, pollex or thumb, the anterior digit of the manus; *Pr*, primus or great-toe, the anterior dactyl of the pes, which becomes the *outer* in the older bats, but is the *inner* with most animals; *W*, web, the fold of skin which connects the digits with each other and with the leg and margin of the trunk; *C*, calcar, a spur-like process from the heel, serving to extend the web which reaches between the legs and the tail; *Ear*, the ear; in Fig. 7 *H* is the heart; in Fig. 10 *A* is the rounded prominence corresponding to the cerebral hemispheres which are developed from the anterior cerebral vesicle; *M* represents the optic lobes, formed from the middle vesicle; *N*, nostril; *Mo*, mouth; *E*, elbow; *K*, knee. For further explanation, see the text.

[1] Figs. 5 to 11 were all drawn and engraved from nature by Mr. Philip Barnard.

noting, however, that the manus is already a little the wider and more prominent.

In Fig. 7 the manus is not only larger but has protruded so as to display the wrist and elbow regions, and a slight prominence upon the anterior border marks the position of the thumb (pollex). In these three specimens I have not as yet found the ear, but in 3 and 4 the eye is quite apparent.

In Fig. 6 the ear is a triangular flap, as in most early mammalian embryos.[1]

The manus and pes have enlarged and present shaded portions corresponding with the thinner tissue between the finger and toes. In the former this is to become the web; in the latter it is wholly removed so as to leave the toes free. The muzzle is partly covered by the manus, but it is already somewhat pointed, as in the next figure.

In Fig. 9 the manus and pes of the left side are shown as if removed from the trunk, so as to expose the flat and prominent muzzle. The ear is a large flap, but still projects forward so as to cover the opening. The pollex has separated from the other digits, and the latter are elongated and bent downward. The pes is longer and the signs of subdivision more distinct. A web connected the limbs and the trunk as in the older specimens, but it was somewhat torn, so that the exact extent could not be determined, and I preferred to wait for a better specimen to show it.

The specimens above described were taken from a Brazilian species, *Nyctinomus Brasiliensis* (which is also found in this country). Figs. 10 and 11 were from the common "little brown bat" (*Vespertilio subulatus*). As might be expected, the increasing limbs are packed about the body more or less irregularly. But in Fig. 10 the limbs of the two sides are placed with almost exact symmetry so as to cover the face and the body. One eye is covered, the other peeps out over the index-finger. The ears are firmly held down by the thumbs, and one of the nostrils is partly hidden by the web. The lower part of the trunk and the tail are bent upward, and the knees are thrown outward so as to bring the great-toe (*pr*) upon the outer instead of the inner side. The whole suggests an effort upon the part of the embryo to not only occupy the least possible space, but also to screen itself from observation, and neither see, nor hear, nor smell.

In Fig. 11 is shown an older embryo, of natural size, outspread so as to display the characteristic features of bats; the greatly-elongated fingers; the separation of the thumb; and the extension of the web, with the reticulated arrangement of vessels and nerves upon it. This nervous expansion seems to enable bats to perceive the proximity of bodies by the change in the pressure of the air.

[1] It remains to be seen whether the seals, whales, manatee, and dugong, have a pinna in the earlier stages, and afterward lose it. Upon the earliest embryo of a manatee yet known, see a paper by the writer in *American Journal of Science*, August, 1875.

THE SIZE OF BAT FAMILIES.—It is not known that bats make a nest like birds, or that they have any other way of caring for their young than by carrying them hanging to their fur whether during flight or while suspended at rest by the legs.

So we might naturally infer two things: first, that the young bats would be born in a somewhat advanced condition so as to be able as soon as possible to shift for themselves; and, second, that the number produced at a birth would be small.

The former inference would seem to be true, judging from the large size of the little bats before birth, and the rarity of the capture of the mothers with young. In one case the two unborn young weighed two-thirds as much as the parent, and the average of twenty individuals gave the weight of the young as four-tenths that of the parents.

Upon the second point it is stated by Van der Hoeven ("Handbook of Zoölogy," vol. ii., p. 731) that "bats commonly produce one or two young ones at a birth;" but he does not say upon how many observations the conclusion is based.

Prof. Owen ("Comparative Anatomy of Vertebrates," vol. iii., p. 730) records two observations of bats (*Vespertilio emarginatus* and *V. noctula*), with each one young, and concludes that this is commonly the case with all bats.

A collared fruit bat (*Cynonycteris collaris*) produced a single young February 27, 1870, and a second April 7, 1871.[1]

In Jamaica Mr. Osborn observed several females of *Molossus fumarius* and *Monophyllus poeyi*, with each one young.[2]

The same observer mentions two other species (*Macrotus Waterhousii*, and *Monophyllus Redmanii*), without specifying the number of young; but we may infer that, as in the other cases, each female had but one.

In a single female of an undetermined Brazilian species I have found one young; and in each of forty females of the *Nyctinomus Brasiliensis* (from Brazil) a single young.

These are certainly facts in corroboration of the opinions of Owen and Van der Hoeven, but let us not be hasty in generalizing from them respecting all bats.

In June, 1874, there were brought to me twenty females of the "little brown bat" (*Vespertilio subulatus*). Each was found to contain *two* little bats in various stages of development.[3]

Finally, Prof. Putnam, of the Peabody Academy of Science, has kindly allowed me to examine two females of the *Lasiurus noveboracensis* taken in Massachusetts, on each of which were *three* young bats.

The foregoing observations indicate that, while one is the more

[1] P. L. Sclater, "Proceedings of Zoölogical Society, 1870, 1871."

[2] "Proceedings of Zoölogical Society, 1865," p. 81.

[3] I have since seen a bat of another species, to which were clinging two young.

common number of young produced by bats, two and three may occur. More extended inquiry may show that these larger families are less rare than now appears, and even that as many as four young may be produced at a birth. For while bats are usually credited with only two nipples, an extra pair exists upon the *Lasiurus noveboracensis*.

The uniformity in number with each species is very striking. Twenty-two of one species had each two young, while forty of another had each one.

In the former case the young were placed one on the right and the other on the left of the body. But in the latter case the single young was invariably on the right side; while, in the single specimen of the undetermined Brazilian bat, the young was on the left side.

Equally striking with the above facts is the isolation of the females with young. Among forty-three *Nyctinomus Brasiliensis* was but a single male. No males were found near the twenty-two *Vespertilio subulatus*. Osborn says that, of *Molossus fumarius*, all of one large lot were males; while at another time, in a large hollow tree, he found in one cavity about one hundred males, and in a second about the same number of females, with "apparently a few males here and there."

Evidently there is much to be learned respecting the domestic and social economy of these animals. Perhaps the males gather food for the females.[1]

Perhaps the most important fact, from a practical point of view, is that of the power of the mother-bats to carry such a weight of young in addition to their own. Yet, so far as I know, all estimates of the extent of wing and size of muscle, which would be necessary to enable a man to fly, have been based upon the idea that the only flying mammal is a fair standard.[2]

These estimates should be corrected so as to conform to the fact that a bat can fly with nearly double its ordinary weight. Even this may not encourage us to hope for a future race of flying-men. But it renders it worth considering whether a man, naturally slight of frame, with small head, could not so far reduce his weight by a flesh diet, and by the amputation of his legs, as to enable him, by special cultivation of his pectoral muscles, to work effectively a pair of wings less extensive than those now supposed to be required.

[1] The writer has not been able to examine the development of bats with the nasal appendages. He would be glad to receive information upon the habits of bats with young, and to exchange the latter for specimens of *Amphioxus*.

[2] Harting ("Archives Néerlandisches," iv.) calculated that a bat the size of a man would require wings two and a half metres long, and with a surface of one and a half square metre.

# INSTINCT AND INTELLIGENCE.[1]

By Prof. JOSEPH LE CONTE.

WHAT is instinct? What is its relation to intelligence? These questions form the subject of my lecture to-day.

Many persons would probably object to this subject being treated at all in a course of physiology. Many persons doubtless think that these are questions for the psychologist, and not for the physiologist. But I think you have already perceived, in the course of these lectures, how difficult, yea, impossible, it is to sharply separate these two departments. As between all other departments of science, so also between these, there is a border-land, which is common ground. The physiology of the brain is that common ground.

The precise relation of physiology to psychology it is extremely difficult to adjust. As there are two opposite errors in regard to vital force—one, the old error of regarding this force as something innate, underived, unrelated to other forces of Nature; the other, the new error of regarding it as nothing but ordinary physical and chemical forces, and thus *identifying physiology with chemistry and physics*—so also on this subject there are two opposite errors: one the old error of regarding mental forces as wholly unrelated to and underived from vital forces, and psychology, as wholly disconnected from physiology; the other, the new error of regarding mental phenomena as connected with the brain in the same clear and intelligible way that functions are connected with organs, and *thus identifying psychology with physiology*. But, as in the case of vital force, there is a truer view, viz., that which regards this force as indeed correlated with other lower forces and derived from them, but, nevertheless, as a very distinct *form* of force or cosmic energy, producing a very distinct and peculiar group of phenomena, the knowledge of which constitutes the science of physiology; so also, on the subject of mental force, there is a truer view which comprehends and embraces the extremes mentioned above.

Let me briefly explain my views on this subject. In recent times physiology has indeed made great, and to many startling, advances in the direction of connecting mental phenomena with brain-changes. Physiologists have established the correlation of physical and chemical with vital forces, and probably of vital with mental forces. They have proved in every act of perception the existence of a vibratory thrill passing along the nerve-cord from sense-organ to brain; and in every act of volition a similar vibratory thrill from brain to muscle; they have even determined the velocity of this vibratory thrill, and find it, to the surprise of those who identify nervous force with elec-

[1] A Lecture to the Class in Comparative Physiology in the University of California.

tricity, only *about* 100 *feet per second.* They have also established the fact of a chemical or molecular change in the brain corresponding with changes in mental states; and with great probability, also, a quantitative relation between these corresponding changes, and therefore a *relation between them of cause and effect.* In the near future we may do more: we may localize all the faculties and powers of the mind in different parts of the brain, each in its several place, and thus lay the foundations of a scientific phrenology. In the *far-distant future* we may do even much more: we may possibly connect every different kind of mental state with a different and distinctive kind of molecular or chemical change in the brain; we may find, for example, that a right-handed rotation of atoms is associated with love, and a left-handed rotation with hate. We may do all this, and much more. We may push our knowledge in this direction as far as the boldest imagination can reach, and even then we are no nearer the solution of this mystery than before. Even then it would be impossible for us to understand *how* brain-changes can produce even the simplest psychological phenomena such as *sensation*, *consciousness*, *will.* By no fort of the mind can we conceive *how* molecular *motion* can produce *sensation* or *consciousness.* The two sets of phenomena belong to different orders—orders so different, that it is simply impossible to construe the one in terms of the other.

It is not thus with other groups of phenomena in relation to one another. The phenomena of motion, heat, gravity, light, electricity, chemical affinity—yea, also of vitality—have been, or may be, construed in terms of each other, and all in terms of *molecular motion.* Whether our present theories on this subject be true or not, may admit of doubt; but a true theory is at least conceivable; all these may conceivably be reduced to the same order. But no amount of knowledge nor strength of imagination will in the least degree help us to understand the mysterious causal relation between the molecular changes in the brain and the corresponding effects in the mind, or between changes in the mind and corresponding changes in the brain.

I wish to put this as clearly and as strongly as I can. Suppose, then, an *infinite human* knowledge—infinite in *degree*, but human in *kind;* suppose, in other words, an absolutely perfect science, such as was conceived and admirably expressed by Laplace—a science which had completely subdued its whole domain and reduced it to the greatest simplicity, so that the whole cosmos and its phenomena is expressed by a single mathematical formula, which, worked out with positive signs, would give every phenomenon which would ever occur in the future, or with negative signs every event which had ever occurred in the past. Even to such an infinitely perfect science the causal relation of molecular motion on the one hand to sensation, consciousness, thought, and emotion on the other, or *vice versa*, would still be utterly unintelligible. Like the essential nature of matter, or

the ultimate cause of force, this relation lies outside the domain of science.

But, admitting this chasm which cannot be bridged—admitting the distinctness of psychology and physiology, a distinctness far greater than exists between any other two departments of science—still there can be no doubt that the changes in the brain and in the mind correspond with each other in the strictest manner. There can be no doubt that we have here two parallel series running side by side with corresponding terms, and that every change in the terms of one series is associated with a change in the corresponding terms of the other series. Whichsoever we take as cause, and whichsoever as effect, the correspondence is undoubted. This much seems certain, and this is sufficient to show that a knowledge of the terms of one series must throw light on the order of succession in the terms of the other series. In a word, *physiology*, as the simpler and more fundamental science, *must form the only true basis of a scientific psychology.*

Again, as anatomy only became scientific by becoming *comparative* anatomy, i. e., by the study of the *structure* of organisms in their relation to each other, or as connected by the law of evolution; as physiology, too, only became really scientific by becoming *comparative* physiology; i. e., by tracing the gradual evolution of organic *functions;* even so psychology can never assume the rank of a science until it becomes *comparative* psychology; i. e., until it adopts the comparative method, until it studies the different grades and kinds of mentality in their relation to each other, and connects them all by the law of evolution.

So much I have thought it necessary to say in order to show the importance of my subject, and its close connection with physiology. I now pass on to the subject itself.

It is well known that many of the lower animals, especially certain species of insects, perform acts perfectly adapted to accomplish results, and that *without previous experience and without instruction.* Often the results attained are of a very complex character; results which could not be attained by ourselves except by the exercise of high intelligence, aided by much experience. The extraordinary capacity by which these results are reached with such unerring certainty is called *instinct.*

I need hardly refer you to examples: You are all familiar with the wonderful instinct of the common honey-bee; their organized communities with perfect division of labor, the precision with which they make their honey-cells on perfect mathematical principles, the honors paid to their queen, their care of her eggs, their wise distribution of food to the larvæ, both its quality and quantity, and the form and size of the containing cells being varied according to the function and even to some extent determining the character of the perfect insect, whether drone, or queen, or worker. You are already familiar with

all this and much more which I cannot stop to recapitulate. You are also doubtless familiar with the still more wonderfully organized communities of ants, with their queens, their domestic laborers, and their warriors. You have heard of, if you have not watched, their marauding excursions, their fierce but well-ordered battles, the triumphal return of the victors laden with spoil, and with captives whom they reduce to the condition of domestic servants. I barely mention these examples because they are familiar to all, but I must describe more fully one case of instinct from the same family, which is probably less familiar to you and yet no less wonderful: I refer to the case of the common mud-wasp or clay-dauber.

These insects do not form organized communities, and therefore have no neuters or workers, but each female works for herself. Neither does she feed her young as do bees and other wasps, but provides appropriate food in abundance, and leaves them to themselves. But the mode of building her cells and supplying the appropriate food exhibits a marvelous wisdom. She gathers wet clay in pellets about the size of a duck-shot and commences to build. Going and coming from her clay-quarry to her work, with great patience, industry, and skill, she builds two or three cells side by side, two or three inches long and about half an inch in diameter. When finished she proceeds to fill them with food. For this purpose she attacks all varieties of spiders, stings them, plunging her sting with the greatest precision directly into the principal nerve-ganglion, and, after laying an egg in the body of each, carries them off and packs them away in the cells, until these are completely full, then seals them with clay and leaves them. In due time the eggs are hatched, the larvæ feed upon the spiders, until they become perfect insects, and cut their way out of the cells.

Observe, then, first, the walls of the cells must be thin and composed of porous materials, otherwise the eggs could not hatch, nor the larvæ continue to live, for want of oxygen; second, the spiders must be *helpless but not dead.* If they were dead they would decompose or else dry up before they could be used as food. If, on the other hand, they were alive and active, they would destroy each other, and the contained eggs, and perhaps escape from the cell. But the poison is so adjusted as to quantity, and probably as to the place of insertion, as to produce a state of complete helplessness, a deep *and permanent coma:* the spiders are as it were chloroformed by the poison. If touched or irritated, they move only enough to show that they are not dead. As a boy I have many times watched these wasps gathering their materials, building their cells, gathering their food-supply of spiders. I have many times broken open their finished cells and found them full of spiders in the condition described. If one desires to study spiders, he can gather more varieties in one day, by breaking open the cells of mud-wasps, than in a year in any other way.

Now, such actions performed by man would show high intelligence and much experience; and yet we cannot attribute such intelligence to these insects, because their actions in other directions and under other and new conditions exhibit but a very small amount of intelligence; we are compelled to attribute these wise actions to another and somewhat different faculty, which by way of distinction we call instinct. Let, us then, contrast these two faculties (if they may be so called) and show their distinctive features:

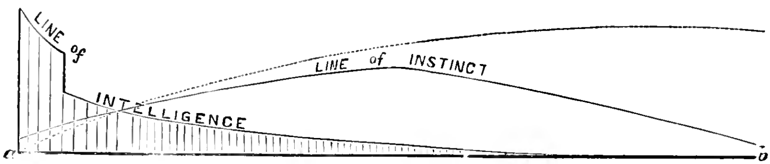
1. *Intelligence works by experience, and is wholly dependent on individual experience for the wisdom of its actions.*—Wisdom in this case is a product of two factors, intelligence and individual experience. Intelligence alone produces nothing. Experience alone is equally valueless. With a given intelligence the product will vary as the experience, with a given amount of experience the product will vary as the intelligence. Thus intelligence works by experience to attain wise results. On the contrary, instinct is wholly independent of individual experience. The young bee or mud-wasp, untaught, works at once without hesitation, with the greatest precision and in the wisest manner, to accomplish the most marvelous results. Like the reflex function of the nervous system, and like the still lower organic functions of secretion, excretion, circulation, respiration, etc., *the wisdom and precision of its actions seem to be the result of structure*, though unlike these the actions are not removed from the sphere of consciousness and will, if we call it intelligence; then it is not *individual* intelligence but *cosmic intelligence*, or the *laws of Nature* working through inherited brain-structure to produce wise results.

2. *Intelligence belongs to the individual, and is therefore variable*, i. e., *different in different individuals, and also improvable in the life of the individual by experience.*—Instinct *belongs to the species*, and is therefore the same in all individuals and unimprovable with age and experience. It is true that close observation would probably detect a slight difference in the skill of different bees, and slight improvement with age, in some more than others, but this must be accredited to the individual, not to the inherited element, i. e., to the small margin of intelligence which undoubtedly exists in these animals.

3. *Instinct in its sphere is far more perfect and unerring than intelligence.*—It makes no mistakes, because determined by structure, not by imperfect knowledge.

In a word, intelligent conduct is *self-determined* and becomes wise by individual experience. Instinctive conduct is *predetermined in wisdom by brain-structure.* The former is free, the latter is to a large extent automatic; the one is like the voluntary locomotion of the higher animals, free to turn whither it likes, but liable to mistakes and stumblings and hurtful falls; the other like the motion of an engine laid upon a track which bears it swiftly and surely to its destined goal.

I have given, thus far, only a few very conspicuous examples of instinct, in order the more clearly to contrast this faculty with intelligence. I might have added many other conspicuous and well recognized examples, such as the migrations and nest-making of birds, the dam-building of beavers, etc. But we would have a very imperfect notion of the wideness of the operation of instinct if we confined ourselves to these conspicuous cases. Instinct in a less remarkable degree is *universal* among animals, including man himself. But what is universal in the popular mind creates no surprise, attracts no attention, and seems to need no explanation; yet it is these very universal and therefore unobserved phenomena which are the most instructive to science. Not only the action of bees and ants and wasps, not only the migrations and the nest-making of birds and the dam-building of beavers, must be accredited to instinct, but also all *complex voluntary motions which are performed without experience.* Such, for example, in many animals are the acts of running, swimming, flying, walking, and standing, etc. Yes, even the simple act of *standing* or walking is really a marvelous feat in balancing—requiring the nice adjustment and perfect coördination of perhaps a hundred different muscles. Even the simple voluntary act of sight (looking) requires the most exquisite adjustment of the optic axes, the lenses, and the iris. These complex actions are acquired by *us* by *experience*, though there is doubtless also, *even in us, a large inherited element*, an inherited capacity by which we acquire them with comparative facility. But the new-born ruminant quadruped or gallinaceous bird *stands* and *walks* and *uses the eyes at once, without experience.* The power to coördinate these muscles, and to accomplish these complex and difficult actions, is wholly inherited, not acquired.[1]




Thus defined, intelligence and instinct are not mutually exclusive, as some seem to suppose: the one is not simply a characteristic of man and the other of animals, but they coexist in varying relative proportions throughout the animal kingdom. As a broad general fact, in going down the animal scale we find that *instinct varies inversely as intelligence.*[2] The accompanying diagram expresses in a general way this relation. If the line *a b* represents the animal scale from

[1] "Instinct in New-born Chickens." *Naturalist*, vol. vii., pp. 300, 377, 384.

[2] As we are not dealing here with measurable quantities, of course I do not use the expression "varies inversely as" in a strict mathematical sense.

man down to the lowest radiate, and upon this as absciss we erect ordinates representing the degrees of intelligence, then by connecting these ordinates we develop what might be called the *line of intelligence.* This line, as is seen, rapidly descends from the higher to the lower races of man, then makes a sudden fall from the lowest races of men to the highest species of monkeys, and thence gradually descends until the ordinates of intelligence become insensible, though they probably still exist down to the lowest point, *b*. If in a similar way we construct a line of instinct, it would probably rise as we pass down through the lower races of men and through the animal scale, reaching its maximum about the middle of the series among insects, and again declining to the end. If, however, we were to construct a third line representing the relative amounts of these two, i. e., the *proportion of instinct to intelligence*, it would probably be a continuously rising curve something like the dotted line in the diagram. The quotient of instinct divided by intelligence, of acquired wisdom divided by inherited wisdom, constantly increases as we go down the scale.

Such, then, is the nature of instinct, and such its general relations to intelligence. But the most important question still remains. How was this wondrous faculty acquired? Whence did it come? How is it derived? In a word, what is the true theory of the *origin of instinct?*

The Origin of Instinct.—The *old* theology disposes of the above question, as she does so many others, in the most summary way. According to her, instincts are not acquired or derived at all. They are miraculously given in perfection to the first individuals of the species, to each species its several kind. But this explanation cannot satisfy Science. It simply places the question beyond her domain. To science Nature is a continuous chain, and her mission is to recover every link. To her a true explanation of any phenomenon consists in connecting it with other phenomena most nearly allied to it. A scientific explanation or theory of instinct must connect it with intelligence on the one hand and the lower phenomena of the nervous system on the other—must show how all these several capacities are evolved the one from the other—must bring them all under the universal law of evolution.

This, it is admitted, is no easy task. The wonderful instincts of some animals have always been regarded as one of the greatest objections to the theory of evolution. The origin of instinct is reckoned one of the hardest nuts for evolutionists to crack. The subject is indeed an obscure one, but recently some light begins to break. The task is indeed a hard one, but I believe we begin to understand in what direction, at least, we must work. The question is yet far from solved—we are yet in much perplexity, but I think we hold the thread which must eventually lead us out of this labyrinth. I have thought much for many years on this subject, and I now give you the views

which have gradually grown up in my mind. Others, I observe, perhaps nearly all evolutionists, are thinking in much the same direction, but I have not yet seen any distinct presentation of the subject.

The movements of the animal body, you will remember, are divided into two great groups, the voluntary and the involuntary or reflex. But between these extremes there are undoubtedly many intermediate terms connecting them. Thus is it in all our science, and still more in our systematic teaching of science. *Our* distinctions are far more trenchant than the distinctions in Nature. It must and ought to be so, for we must get firm hold of the types first, and then we are prepared to study the intermediate gradations. Of the intermediate terms in this case there are *two* which are quite distinct. Including the extremes, therefore, we have four kinds of animal movements:

1. *The perfect voluntary movements.*—These require the full, constant, and immediate exercise of the will; and, when the movement is complex, requiring in addition the whole thought and attention fixed, often painfully fixed, on the movement. In this category are nearly all movements when accomplished for the first time.

2. *Habitual movements.*—These are *semi-volitional.* They are removed from thoughtful attention, from immediate and painful effort of the will. A general superintendence only of the will is necessary. When any thing goes wrong the mind takes cognizance and corrects it by direct act of the will, and the movement falls, for the time being, into the first category; but otherwise the thoughts and attention may be directed to something else. These are, therefore, to some extent, automatic. Such are, in man at least, the movements in walking, flying, swimming, speaking, playing on a musical instrument, etc. These were, in all cases, at first movements of the first kind, but fell into the second category by *repetition.* They are *acquired*, therefore, wholly by *individual experience.*

3. *Instinctive movements or acts.*—These are still farther removed from the category of the first group. They are *removed*, not only from thoughtful attention, but *also from indvidual experience.* If we compare them with habitual acts, they are *inherited habits.* They are evidently the result of *inherited brain-structure*, but they are not yet wholly removed from the sphere of consciousness and will. Such are the actions of bees and other insects already described.

4. Lastly, *Reflex movements.*—These are wholly automatic. They are wholly removed not only from thoughtful attention and individual experience, but also from consciousness and will. These are therefore the extreme type of movements determined with the greatest precision by inherited structure of the nervous centres. Such are the movements of the heart, the stomach, the intestines, etc.

Now, of these four kinds of acts, 1 and 2 and 3 are evidently formed the one from another, i. e., 2 from 1 and 3 from 2. The fourth I cannot account for in a similar way, for it must have preceded all the

others. And this convinces me that there is yet a higher philosophy on this subject which I have not reached.

Formation of Habits.—We are all familiar with this process. A movement or series of movements at first painfully difficult, and requiring the whole thought and attention, by repetition become so easy and semi-automatic that attention is no longer necessary. The most remarkable examples of these, such as walking, speaking, and the like, probably belong partly to the third category; the capacity for these is partly inherited. Playing on a musical instrument is therefore a better example. We all know the painful attention necessary at first, and the ease and rapidity of the most complex movements attained by practice. Now, by what means, anatomical or physiological, do these at first difficult movements become by repetition easy? The answer in general terms seems to be this: Every volitional act is attended with a change in the brain, which, however, is slight, liable to be effaced by subsequent changes, and therefore *evanescent*. If the same act, however, be repeated many times, the change becomes deep and *permanent*—becomes *petrified in brain-structure*; and this structure, whatever be its character or its seat, determines the appropriate acts with precision. It is as if every volitional act produced a faint line, liable to be erased, on the tablet of the brain; by running over the same lines many times, these are deepened into grooves and finally into *ruts*, and motion in these becomes easy and certain because the ruts guide the motion instead of the will. Thus repetition produces structure and structure determines habit.

Formation of Instincts.—The structure produced by repetition of voluntary acts, and which, as we have seen, determines habits, by the law of inheritance is transmitted in a slight degree to the next generation. I say in a *slight degree* only, because inheritance is from the whole line of ancestry and not from the immediate parents alone. The inheritance from the immediate parents is greater, it is true, than from any *one* of the series of previous generations, but infinitely less than the *sum* of inheritances from *all* previous generations. The structure may be regarded, therefore, as transmitted in an almost effaced condition. If the same acts are not repeated, the lines of structure are soon wholly effaced by new lines running across the tablet in all directions; but if they are repeated the same lines are deepened with greater ease and certainty than before; the structure becomes still more decided, the habit still more fixed. This more deeply-engraved structure is again partially transmitted to be again strengthened in the next generation—the engraved plate is retouched and the lines deepened. Thus with every generation the sum of inheritance becomes greater because from a greater number of preceding generations; with every generation the effacement by transmission is less, and the deepening by repetition is greater, until finally a highly-differentiated structure is formed, and *perfectly transmitted*—a structure

with lines so deep as to determine the direction of conduct with the greatest certainty. *Then habit becomes instinct.* The individual no longer forms the structure, but inherits it ready formed. The actions are no longer learned by practice, they are already predetermined by the inherited structure.

We see illustrations of this process in the artificial formation—the deliberate manufacture—of instincts in domestic animals by human training and human selection. We know that the instincts of the pointer and the shepherd's dog have been formed in this way. The great ancestor of all the pointers, before he was a pointer, was trained with much coaxing and many beatings to do certain things. The result was doubtless any thing but satisfactory. Still a habit was formed, and, as we must believe, a corresponding brain-structure. The pups of this dog were again trained, still with difficulty, but with less difficulty than before, because the habit-structure was partially inherited. The best-trained of this generation are selected, and their pups again trained. The process is still easier, because the habit-structure is more completely inherited, and the result is more satisfactory, because the structure is more decided. Thus the improvement goes on from generation to generation, until finally, in the purest bloods, i. e., those having the longest line of well-trained ancestry, without mixture with effacing bloods, little or no training at all is required; the habit-structure is almost perfectly transmitted. Perhaps in this case transmitted habit never becomes perfect instinct; probably the best-blooded pups still require training. But this is because the process has not been continued long enough, the breeding has not been true enough, and the selection careful enough.

Now, if pointers or shepherds' dogs should become wild, their instincts would quickly be destroyed by natural selection, because they are not useful, but, on the contrary, hurtful, in the wild state. But, suppose they were useful in the struggle for life, then the habit thus acquired would be transmitted, and become strengthened with every generation, until it would become as perfectly fixed and invariable as any, even the most perfect instinct.

Now, it is precisely in this way that the wonderful instincts of bees and ants and the wonderful instinctive coördination of muscles in ruminants and gallinaceous birds have been formed, except that in these cases *natural* training and *natural* selection have operated instead of *human* training and *human* selection. The great ancestor of all the bees, before the distinctive characters of the bee yet existed, was doubtless destitute of the wonderful instincts which we now find. These have been gradually formed and improved from generation to generation through many hundred thousands of years.

It is difficult to imagine, much more to express, all the steps of this process. I will, therefore, illustrate it in the following manner: We have seen that wise conduct is a product of intelligence and expe-

rience. Evidently, therefore, great wisdom may be attained even with small intelligence, if only the experience be proportionally great. Wisdom increases with experience without limit, if only the plasticity of the brain, or its capacity to receive and retain impressions, remain unimpaired. Now, suppose a number of the ancestors of the bees many hundred thousand years ago, before these specific instincts were developed; suppose, further, that these *individual insects had continued to live from that time to this*, and retained their brain-plasticity unimpaired. Even with the smallest modicum of intelligence, such instincts would, by experience, slowly improve their habits from year to year, from century to century, from millennium to millennium, until they would reach a surprising skill in accomplishing the most complex results. This would be *habit*, not instinct. The habit so long forming, so useful, and therefore so invariable, would of course be embodied in a very decided brain-structure. Now, precisely the same result is far more perfectly reached by the experience of many generations transmitted and accumulated by the law of inheritance. I say *more perfectly*, because of the natural selection of only the fittest in each generation.

Thus we see that instinctive wisdom is also the result of experience, but it is *ancestral*, and not individual experience. Individual experience is first fixed in habit, and then habit is transmitted and petrified in instinct. In a note published in the *Philosophical Magazine*, April, 1871, I speak of instinct as "*inherited experience*." I did not then know that I had been anticipated by a few months by Hering ("Archives des Science," February, 1871), who calls instinct "*inherited memory*." These are but different modes of expressing the same idea. Intelligence works by *individual experience* treasured in *memory;* instinct by *racial* or *communal experience* treasured in *inherited structure.* But memory is evidently the result of brain-structure formed by experience; therefore also is instinct *inherited memory.* Again, knowledge is remembered experience; therefore is instinct also *inherited knowledge.* Thus *experience*, *memory*, *knowledge*, things which seem to us so indissolubly connected with *individual identity*, are also sometimes inherited.

Thus, then, the sum of experience and the mental wealth which is accumulated by experience consists of two parts, individual and inherited. In man the *individual* acquisition is large, and the inheritance is comparatively small. In the lower animals the individual acquisition is small, while the inheritance is large. In bees the wealth is almost wholly inheritance.

We now easily see why intelligence varies inversely as instinct—why high intelligence seems incompatible with remarkable and invariable instinct. It is because, with high intelligence, actions are *so varied*, in different individuals and in different generations, that it is impossible that their results should accumulate and become petrified in structure. But, in the lower animals, the conditions of life are nar-

row, the habits necessary for successful struggle for life *run in few lines*, and these lines become deepened with every generation, until they become, as it were, petrified in brain-structure.

Instinct, therefore, is accumulated experience, or knowledge of many generations fixed permanently and petrified in brain-structure. All such petrifaction arrests development, because unadaptable to new conditions. They are found, therefore, only in classes and families *widely differentiated from the main stem of evolution*, from the lowest animals to man. Instincts are, indeed, the flower and fruit at the end of these widely-differentiated branches, but flowering and fruiting arrest onward growth.

Now, there is also a *social* evolution. The organic evolution, which found its term in man, is continued by man in social evolution. It is natural, therefore, to look for the corresponding phenomenon in the higher sphere of social evolution. I believe we find it in the phenomenon of *arrested civilizations*, of which nearly all barbarous and semi-civilized races are examples, but the Chinese and Japanese are the most conspicuous; and also, perhaps, to some extent, in the phenomenon of dead civilizations, of which the Greek and Roman are the most conspicuous. Nations *isolated* and *breeding true*, i. e., without mixture with other nations, gradually assume fixed customs and habits which become enforced, and therefore perpetuated by law, and finally *petrified in national character*. The result is often marvelous development, but extremely *limited*. Here, again, perfect flower and fruit destroy growth. Here again, also, it occurs in a type or branch widely differentiated from the main stem of social progress. This explains one of the advantages of cross-breeding, or mixing of varieties within certain limits of national varieties, if not of races.[1] It confers plasticity; it prevents the formation of fixed national character, and the consequent arrest of progress by petrifaction.

Let us hope, then, that the growing tree of society will always remain an *excurrent;* that its upshooting stem shall never lose itself in mere branches; that its terminal bud shall never fail, but always continue to grow. Its branches may flower, and fruit, and die, or cease to grow, but the trunk stretches ever upward and bears each successive flowering branch higher and still higher. Doubtless the ideal of humanity is that all right actions are spontaneously or instinctively performed, and all important truths intuitively or instinctively known; but this is and must be an unattainable ideal; for, this condition reached, how shall we any longer aspire?—the terminal bud flowering, how shall the tree continue to grow? Human nature must never petrify into instinct; inherited wealth must never supersede the necessity of individual acquirement.

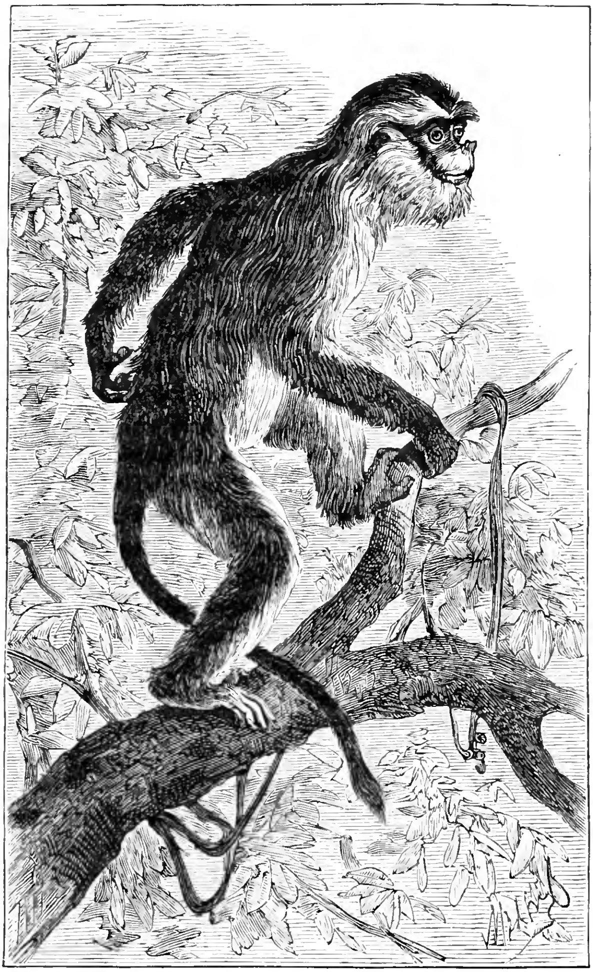
[1] The effect of mixing varieties requires careful investigation, for it is yet very imperfectly understood. There seems little doubt, however, that there is a limit beyond which varieties do not mix with improvement.

# MONKEYS FROM A COLD CLIMATE.

TRANSLATED FROM THE FRENCH BY J. FITZGERALD, A. M.

FOR upward of ten years, the Abbé Armand David, a Catholic missionary, has devoted himself to studying the fauna and flora of regions in the Chinese Empire previously unvisited by any European naturalist. He has enriched the Paris Museum of Natural History with collections of great value, representing a number of species either new to science, or not known to have their habitat in Eastern Asia. The Abbé David came to Peking in July, 1862, and in the following year made his first remittance to the museum, of natural history specimens collected and prepared by himself. In 1864 he spent several months at a point 125 miles north of Peking, collecting there fresh materials. Two years later he was in Mongolia, where he spent several months. In 1868 he explored the province of Kiangsi, in Central China, discovering several new species. Toward the end of that year he ascended the Yang-tse-kiang, on a steamer, as far as the city of Hanyang. Thence he made the voyage to the ancient city of Ichang, on a junk, navigating a series of lakes and canals. After a week of difficult navigation he again reached the Yang-tse-kiang, and embarked on a junk of greater tonnage for the province of Szchuen; but, landing at Chungking, he left his baggage on board the junk, and himself cut across-country, reaching Chingtu, the capital of Szchuen, after twelve days' travel. Here M. David spent two months, hunting and botanizing in the surrounding country. Toward the end of February, 1869, he was on the road again, traveling westward over a rugged country, till he reached the border of Moupin, an independent principality, situated on the frontier of China proper. Most maps of Eastern Asia make no mention of Moupin, which is inhabited by the Mantzes, a race differing from both the Chinese and the Tibetans, though they resemble the latter rather than the former. This country lies between Kokonor, the K'ham country, and H'lassa, and is separated from Nepaul, Bhotan, and Assam, by the main range of the Himalaya. But the country really forms a part of the Himalaya region, being covered with lofty mountains whose summits are clad with perpetual snow. Hence, though the centre of Moupin is situated between the thirty-first and the thirty-second degree of north latitude, that is to say, in the latitude of Egypt, its winters are extremely cold, the snow persists in the valleys for several months, and, during the rest of the year, the rain and snow fall with great frequency. This constant humidity of the atmosphere gives rise to a very abundant vegetation; on all sides are to be seen magnolias, laurels, and rhododendrons, which often attain a considerable size; and the mountains

are covered half-way up their sides with forests of pine and cedar. In this country, altogether unknown to Europeans, M. David took up his abode, in the midst of a great valley, situated 2,129 metres (about 7,000 feet) above the sea-level, and only one day's journey from Hong-chan-tin, a mountain over 5,000 metres (nearly 16,500 feet) in height, but commanded by still loftier snow-clad peaks on the north and the southwest.



Moupin Monkey (*Rhinopithecus Roxellanæ*).

No sooner had he reached this locality than there arose difficulties apparently insurmountable. A decree had a little before been issued prohibiting the destruction of game of any kind, in view of a new incarnation of the Buddha. But fortunately the native hunters listened to reason, and M. David succeeded in quieting their scruples by means

of money. In this way he secured a number of birds and mammals, of species that one would not have expected to find in that country.

Among the interesting types discovered in Moupin, we must assign the preëminence to a monkey with long hair and *retroussé* nose, which Alphonse Milne-Edwards has described and figured under the name of *Rhinopithecus Roxellanæ.* This species inhabits the mountains in the western portion of Moupin, as also the district of Yaotchy, and as far as Kokonor. Thus it lives in a region where snow remains on the ground during more than six months in the year. According to the hunters, these monkeys are found in the woods, and always in large troops. Usually, they remain on the tops of lofty trees, and feed on the fruit and young shoots of the wild-bamboo. In possessing no cheek-pouches for stowing away food, and in having one tubercle only on the last molar tooth of the lower jaw, they resemble the *Semnopitheci;* but yet they cannot be classed in the same genus, since, both in anatomical structure and in external aspect, the Moupin monkey presents certain peculiarities which entitle it to a special position among simians. Thus, in the *Semnopitheci*, for instance in the simpai, the entellus, and the budeng, or negro-monkey, the limbs are disproportionately long as compared with the body; the thumb of the anterior hands is short and situated very far back; the tail is long and slender; while in the Moupin monkey the limbs are short and very muscular, the body very strongly built, the tail tufted and shorter in proportion than in the entellus. Besides these, there exist several other characteristics which fully justify the making of a new genus for this Moupin monkey. Thus, the anterior and posterior limbs present no considerable disproportion, as is the case with many of the *Semnopitheci;* the upper arm-bone is very long, longer than the forearm, and its circumference is much increased in its articular portion; the radius (one of the bones of the forearm) presents a strong curvature, with its convexity turned forward, the result being that the interosseous space acquires an exceptionally large size; the han l is large and thick, instead of being long and slender, as in the simpai; but the thumb is quite as rudimentary as in the latter species, and its terminal joint barely extends below the extremity of the first metacarpal bone. The bones of the rest of the fingers are very much bent, which enable the hand to grasp a branch very firmly. The thigh-bone is stout and longer than the large bone of the leg. Finally, the finger-bones of the posterior hands (feet) are short and bowed, which circumstance gives to the palm the form of an arch, and the thumb, instead of being almost atrophied, as in the anterior hands, reaches to the extremity of the first phalange of the index-finger.

The conformation of the head indicates an animal of higher intelligence than the macaques and the *Semnopitheci.* Thus the face is but weakly prognathous; or, in other words, the lower jaw, compared

with the forehead, does not offer that bold prominence which is nearly always a token of ferocity. The brain-case is large and well developed posteriorly, and the temporal ridge, i. e., the bony prominence to which are attached the principal muscles of the under jaw, is smaller than in the *Semnopitheci.* The eye-sockets are round, the cheek-bones prominent, and the nasal region, instead of being in a right line with the forehead, as in the mitred monkey and the great monkey of Cochin-China, is deeply depressed, giving to the face a very peculiar expression. The bones of the nose are reduced to an extreme degree, and the openings of the nostrils, especially in the adult, are very large.

The teeth are remarkable for their development, and in the male the canines are long and sharp.

Alphonse Milne-Edwards has published, in his work on the "Natural History of the Mammalia," a detailed description of this monkey, accompanied by a colored plate, from which our engraving is copied. Unfortunately, the engraving cannot give any idea of the coloration of the animal, and hence we must briefly describe it in words.

The Moupin monkey is of considerable size, the adult male measuring one metre and forty centimetres from the extremity of the muzzle to the extremity of the tail. The face is short, turquoise-green in color; the eyes are large, with nut-brown iris; the nose is turned up at the point. It is to this latter peculiarity, which becomes all the more striking as the animal grows older, that the Moupin monkey is indebted for its generic name *Rhinopithecus.*

The skin around the eyes is greenish, and the nose and muzzle almost naked. But the cheek-bones, the jaws, and the superciliary arches, are covered with thick hair. On the forehead, this hair, which is of a bright reddish-yellow color, is mixed with darker hairs tipped with black. The upper part of the head is covered with grayish-black hair, mixed with rust-color; it forms a sort of skull-cap, and is directed toward the back of the head.

The nape of the neck and the shoulders are of the same color as the crown of the head, but the back, and especially the posterior portion of the trunk, is of a more lively and brilliant hue, owing to the presence of numerous yellowish-gray hairs, with reflex of silver. In old individuals the hairs attain the length of ten centimetres (nearly four inches). On the outside of the arms similar hairs are to be seen, though of duller hue, and on the front of the thighs and legs there is a stripe of iron-gray. But the hinder and outside aspect of the thighs is of a very light yellow, and the inner surfaces of the thighs and legs rust-colored, changing to reddish on the upper side of the feet.

The hair of the anterior hands is gray. The tail is thick and tufted, dark gray at the root and whity gray at the tip.

The female is distinguished from the male by certain differences

of coloration. In the former the side of the neck is gray rather than yellowish, and the tail is of a dull and uniform color. In the young monkeys the skull-cap is small, and the sides of the face are ornamented with a sort of whiskers, which disappear in the adult.

The natives give to the species the name of Kin-tsin-heou, i. e., Brown-and-gold monkey. They hunt it for the sake of its skin, which they use as a preventive against rheumatism.

In the same region with the *Rhinopithecus* there live in small troops, on the most inaccessible wooded declivities, other monkeys who display extreme agility, and who hide in caves, like the Magots or apes of Algeria or Gibraltar. These monkeys, it appears, were once very common here, one old hunter having boasted, in the hearing of M. David, of having killed seven or eight hundred of them in one year. Now, however, they are met with but seldom. With their very short tail and the long hair covering their bodies, they resemble the Magot, properly so called, but they are heavy built, and the face is longer. One individual, sent to the museum by the Abbé David, is eighty centimetres (2 ft. 7½ in.) in length; his head is very large compared to his body; the face is bare and flesh-colored, darker and mottled around the eyes, and brownish about the mouth. Tufted whiskers of a bright gray adorn the sides of the head, and the forehead and the crown of the head are covered with short hairs, of a dull-brown color. The hair of the nape of the neck and of the shoulders is nearly as long as that of the Moupin monkey, and dark in color. The breast and belly are grayish. The anterior hands are small, while the posterior hands are well developed and heavily covered with hair on the upper surface. The tail is rudimentary, and the callosities well marked.

The female is smaller than the male; her skin is of a more uniform color, and softer, and her whiskers are not at all so long.

This species, called by Alphonse Milne-Edwards *Macacus Thibetanus*, would seem to be far more brutish than the preceding, for in the male the bony ridges of the skull are very prominent, and resemble those seen in the head of the gorilla.

In a species from Cochin-China, discovered by David, and described by Isidore Geoffrey St.-Hilaire, under the name of *Macaque oursin*, the cranium presents similar ridges, but far less developed. From the information gathered by M. David, it would appear that there exist in Eastern Tibet at least two other species of large, long-tailed monkeys; of these, the one is said to be of a greenish-yellow color, and the other of a deep black.—*La Nature.*

# PHYSICAL FEATURES OF THE COLORADO VALLEY.[1]

By Major J. W. POWELL.

## III. *Water-Sculpture.*

THE more important topographic features in the valley of the Colorado are mountains, hills, hog-backs, bad-lands, alcove-lands, cliffs, buttes, and cañons. The primary agency in the production of these features is upheaval, i. e., upheaval in relation to the level of the sea, though it may possibly be down-throw in relation to the centre of the earth. This movement in portions of the crust of the earth may be by great folds, with anticlinal or synclinal axes, and by monoclinal folds and faults.

The second great agency is erosion, and the action of this agency is conditioned on the character of the displacements above mentioned, the texture and constitution of the rocks, and the amount and relative distribution of the rains.

In a district of country, the different portions of which lie at different altitudes above the sea, the higher the region the greater the amount of rainfall, and hence the eroding agency increases in some well-observed but not accurately-defined ratio, from the low to the high lands. The power of running water, in corrading channels and transporting the products of erosion, increases with the velocity of the stream in geometric ratio, and hence the degradation of the rocks increases with the inclination of the slopes. Thus altitude and inclination both are important elements in the problem.

Let me state this in another way. We may consider the level of the sea to be a grand base-level, below which the dry lands cannot be eroded; but we may also have, for local and temporary purposes, other base levels of erosion, which are the levels of the beds of the principal streams which carry away the products of erosion. (I take some liberty in using the term level in this connection, as the action of a running stream in wearing its channel ceases, for all practical purposes, before its bed has quite reached the level of the lower end of the stream. What I have called the base-level would, in fact, be an imaginary surface, inclining slightly in all its parts toward the lower end of the principal stream draining the area through which the level is supposed to extend, or having the inclination of its parts varied in direction as determined by tributary streams.) Where such a stream crosses a series of rocks in its course, some of which are hard, and others soft, the harder beds form a series of temporary dams, above which the corrasion of the channel through the softer beds is checked,

[1] From "Report on United States Geological and Geographical Survey of the Territories, Second Division," J. W. Powell in charge.

and thus we may have a series of base-levels of erosion, below which the rocks on either side of the river, though exceedingly friable, cannot be degraded. In these districts of country, the first work of rains and rivers is to cut channels, and divide the country into hills, and perhaps mountains, by many meandering grooves or water-courses, and when these have reached their local base-levels, under the existing conditions, the hills are washed down, but not carried entirely away.

With this explanation I may combine the statements concerning elevation and inclination into this single expression, that the more elevated any district of country is, above its base-level of denudation, the more rapidly it is degraded by rains and rivers.

The second condition in the progress of erosion is the character of the beds to be eroded. Softer beds are acted upon more rapidly than the harder. The districts which are composed of softer rocks are rapidly excavated, so as to become valleys or plains, while the districts composed of harder rocks remain longer as hills and mountains.

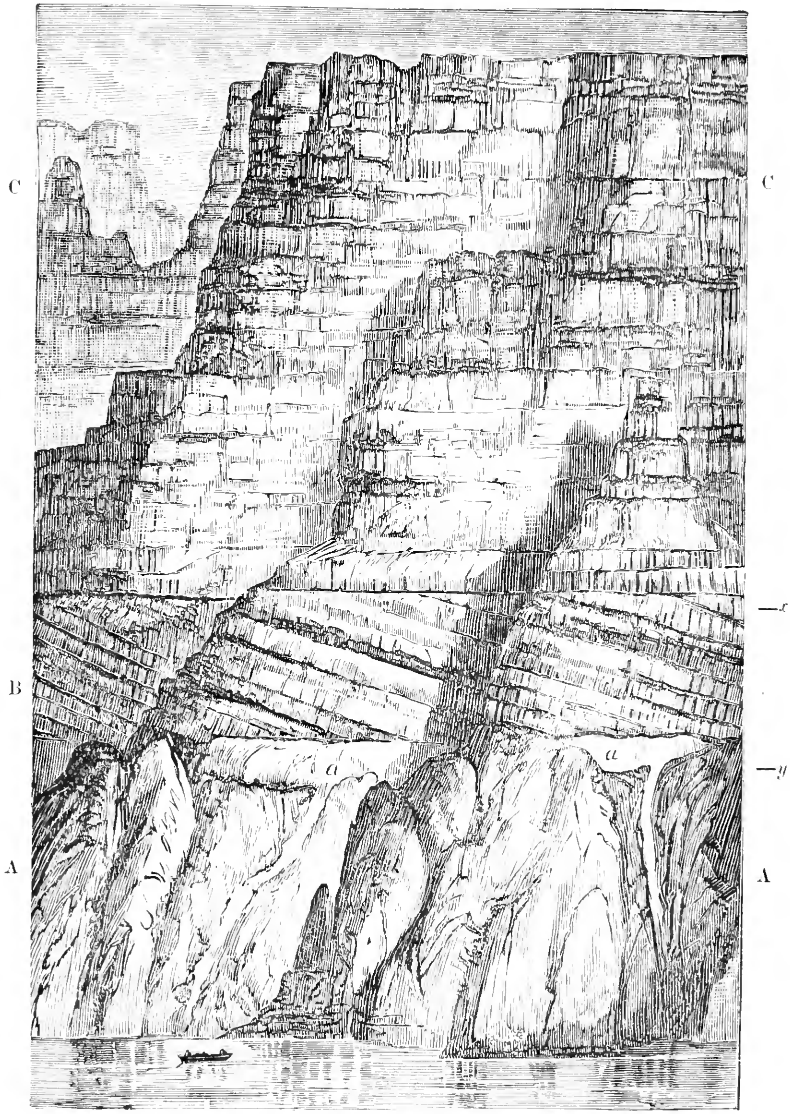
Where the beds are of stratified material, so that the change from harder to softer materials is from bed to bed, rather than from district to district, and in a vertical or inclined direction, rather than an horizontal, the topographic features, which I have described as hog-backs and cliffs of erosion, are produced. The difference between hog-backs and cliffs of erosion is chiefly due to the amount of dip or inclination of the beds.

But there is another condition necessary to the production of cliffs and hog-backs in their typical forms. The country must be arid, for, where there is a great amount of rainfall, the water penetrates and permeates the rocks, and breaks them up, or rots them, to use an expression which has been employed with this meaning; and the difference between the durability of the harder beds and that of the softer is, to some extent, compensated for by this agency, though doubtless ridges and cliffs may be produced in less arid climates, as we find them in the Appalachian System, but not so well marked. In a region of country where there is a greater amount of rainfall, the tendency is to produce hills and mountains, rather than plateaus and ridges, with escarpments.

Now let us examine the character of the channels which running streams carve. Where the rocks to be carved are approximately horizontal, and composed of stratified beds of varying thickness, the tendency is to cut channels with escarpments or cliffs; but if the beds are greatly inclined, or composed of unstratified material, the tendency is to cut channels with more flaring and irregular walls. These tendencies are more clearly defined when the meteorologic conditions are favorable—that is, if a stream cuts through stratified rocks, in an arid region, and carries the waters from a district more plentifully supplied, the cliff character of the walls is increased; and where a

stream runs through unstratified rocks, in a district well supplied with rains, the walls or banks of the stream are cut down in more gentle slopes.

For purposes of discussion, it will be convenient to call the deep




SECTION OF WALL IN THE GRAND CAÑON.

channels of streams through table-lands, in arid climates, cañons; and the deep channels of streams through heterogeneous beds, in a moist climate, water-gaps, or narrows, and ravines.

Having in view the forms which are produced by erosion, it will be convenient to classify the methods of erosion as follows: First, corrasion by running streams, and, second, erosion by rains; the first producing channels along well-defined lines, the second producing the general surface features of the landscape.

Of the first class we have two varieties:

*A.* The corrasion of water-gaps.

*B.* The corrasion of cañons.

Of the second class we have three varieties:

*A.* Cliff erosion, where the beds are slightly inclined, and are of heterogeneous structure, some soft and others hard; and, for the production of the best-marked forms, the climate should be arid. Here the progress of erosion is chiefly by undermining.

*B.* Hog-back erosion, where the beds have a greater inclination, but are still of heterogeneous structure. Here the progress of erosion is by undermining and surface-washing, and the typical forms would require an arid climate.

*C.* Hill and mountain erosion, where the beds may lie in any shape, and be composed of any material not included in the other classes, and the progress of erosion is chiefly by surface-washing. The typical forms are found in a moist climate.

There is still another agency in the production of topographic features, viz., the eruption of molten matter from below the general surface. The beds formed are soon modified by erosion, and then the forms produced are due to that agency, and fall under the general series. But there is a time, immediately after the eruption, when these beds lie in forms due to igneous dynamics, and the most important features produced are cones. These cones are very conspicuous features of the landscape over much of the region drained by the Colorado River.

The district of country drained by the Colorado and its tributaries is divided into two parts, by a well-marked line of displacements. The lower third of the valley, which lies southward from this line, is but little above the level of the sea, except that here and there ranges of mountains are found. From this region, there is usually a bold step to a higher.

The upper two-thirds of the area drained by the Colorado is from 4,000 to 8,000 feet above the level of the sea, with mountain-ranges on the east, north, and west, of greater altitude. The bold step from the lower country to the table-lands is usually an escarpment in rocks of the Carboniferous Age, marked, here and there, by beds of lava, and along its margin stand many volcanic cones. San Francisco Mountain is made up of a group of these beds of eruptive matter, covering stratified rocks. This higher region is the one to which we have given especial attention in the previous discussion.

The principal condensation of moisture occurs on and about the

mountains standing on the rim of the basin, the region within being arid.

Bad-lands, alcove-lands, plains of naked rock, plains of drifting sands, *mesas*, plateaus, buttes, hog-backs, cliffs, volcanic cones, volcanic mountains, cañons, cañon valleys, and valleys, are all found in this region, and make up its topographic features. Mountains, hills, and small elevated valleys, are the features of the irregular boundary belt.

No valley is found along the course of the Colorado, from the Grand Wash toward the sources of the river, until we reach the head of Labyrinth Cañon. For this entire distance the base-level of erosion is below the general surface-level of the country adjacent to the river, but at Gunnison's Valley we have a local base-level of erosion which has resulted in the production of low plains and hills for a number of miles back from the stream. North of the Cañon of Desolation and south of the Uinta Mountains, another local base-level of erosion is found, so near to the general surface of the country that we find a district of valleys and low hills stretching back from Green River, up the Uinta to the west, and White River to the east, for many miles. North of the Uinta Mountains a third local base-level of erosion is seen, but its influence on the topographic features is confined to a small area of 200 or 300 square miles. Going up the chief lateral streams of the Colorado, we find one or more of these local base-levels of erosion, where the streams course through valleys.

Where these local base-levels of erosion exist, forming valley and hill regions, the streams no longer cut their channels deeper, and the waters of the streams, running at a low angle, course slowly along, and are not able to carry away the products of surface-wash, and these are deposited along the flood-plains, in part, and in the valleys, among hills, and on the gentler slopes. This results in a redistribution of the material in irregular beds and aggregations.

In this region, there are occasional local storms of great violence. Such storms may occur in any particular district only at intervals of many years, possibly centuries. When such a one does occur, it reopens great numbers of channels that have been filled by the ordinary wash of rains, and often cuts a new channel through beds which have accumulated in the manner above described. The structure of these beds is well exposed, and we find beds of clay, beds of sand, and beds of gravel occurring in a very irregular way, due to the vicissitudes of local wash, and, where the progress of erosion has been more or less by undermining, larger fragments or bowlders are found, and these bowlders are sometimes mixed with clay, and sometimes with sand and gravel, and where thin sheets of eruptive rocks have been torn to pieces, more or less by undermining (for such is the usual way in this country), the beds appear to contain erratics, and in fact some of the rocks are erratics, for in the various changes in the levels produced

they have often been transported many miles, not by sudden and rapid excursions, but moved a little from time to time.

Again, the beds from which they were derived, doubtless, in many cases have been broken up or lost, and these fragments only remain to attest the existence of such beds in some former time, and all stages may be observed, from the beds the edges only of which have been broken up, to those that have only fragments remaining or have entirely disappeared. Another interesting fact has been observed, that these erratics or bowlders are often found distributed somewhat in lines due to the undermining of lines of cliffs. Often where we have cliffs capped with a bed of lava, former and more advanced positions of these lines of cliffs can be recognized by the position of lines of lava-fragments which are seen in the valley or plains in front of the cliffs. It will be seen that these local accumulations of material, due to the excess of erosion over that of transportation, greatly resemble the accumulations of "the Drift." Especially is this true where I have studied the latter in the valley of the Mississippi, and I have been led to query whether it may not be possible to refer the origin of the Drift of the valley of the Mississippi, in part at least, to some such action as this; not that I question the evidence of extended glacial action in that region, but may it not be that this glacial action has only resulted in somewhat modifying a vast accumulation of irregularly-bedded material, originally due to the fact that the grand base-level of erosion had been reached by the running streams of that region, and hills and mountains had been degraded by having the material of which they were composed scattered over lower lands, without being carried away by streams to the sea?

All the mountain-forms of this region are due to erosion; all the cañons, channels of living rivers and intermittent streams, were carved by the running waters, and they represent an amount of corrasion difficult to comprehend. But the carving of the cañons and mountains is insignificant, when compared with the denudation of the whole area, as evidenced in the cliffs of erosion. Beds hundreds of feet in thickness and hundreds of thousands of square miles in extent, beds of granite and beds of schist, beds of marble and beds of sandstone, crumbling shales and adamantine lavas, have slowly yielded to the silent and unseen powers of the air, and crumbled into dust and been washed away by the rains and carried into the sea by the rivers.

The story we have told is a history of the war of the elements to beat back the march of the lands from ocean-depths.

And yet the conditions necessary to great erosion in the valley of the Colorado are not found to exceed those of many other regions. In fact, the aridity of the climate is such that this may be considered a region of lesser, rather than greater, erosion. We may suppose that, had this country been favored with an amount of rainfall similar to that of the Appalachian country, and many other districts on

the surface of the earth, the base-level of erosion of the entire area would have been the level of the sea; and, under such circumstances, though the erosion would have been much greater than we now find, the evidences of erosion would have been more or less obliterated. As it is, we are able to study erosion in this country, and find evidences of its progress and its great magnitude, from the very fact that the conditions of erosion have been imperfect.

It is proper to remark here that erosion does not increase in ratio to the increase of the precipitation of moisture, as might be supposed; for, with the increase of rains there will be an increase of vegetation, which serves as a protection to the rocks, and distributes erosion more evenly, and it may be that a great increase of rains in this region would only produce a different series of topographic outlines, without greatly increasing the general degradation of the valley of the Colorado.

To a more thorough discussion of this subject I hope to return at some future time.

From the considerations heretofore presented, it is not thought necessary to refer the exhibition of erosion shown in the cañons and cliffs to a more vigorous action of aqueous dynamics than now exists, for, as I have stated, a greater precipitation of moisture would have resulted in a very different class of topographic features. Instead of cañons, we should have had water-gaps and ravines; instead of valleys with cliff-like walls, we should have had valleys bounded by hills and slopes; and if the conclusions to which we have arrived are true, the arid conditions now existing must have extended back for a period of time of sufficient length to produce the present cañons and cliffs. But there are facts which seem to warrant the conclusion that this condition has existed for a much longer period than that necessary for the production of the present features; that is, the characteristics of the present topography have existed for a long time. There are evidences that the lines of cliffs themselves have been carried back for great distances as cliffs by undermining, which is a process carried on only in an arid region.

The evidence is of this character: I have stated that the drainage of the inclined plateaus is usually from the brink of the cliffs backward; i. e., the water falling on the plateau does not find its way immediately over the cliffs, but runs from the very brink or edge of the plateau back toward the middle or farther side, which is usually found against the foot of another line of cliffs, and here the waters are turned toward some greater channel, which runs against the dip and cuts through the cliffs. Now, the water-ways at the heads of these streams that have their sources near the brink of the cliffs would always be small, shallow, and ramifying into many minute branches if the line of cliffs were a fixed or immovable line, but we often find that the cliffs have been carried back by the undermining process until all

these minute ramifications have been cut off; and we find cañons opening on the faces of the cliffs, the waters of which run backward as above described.

Let us suppose that we have a line of cliffs with an escarpment facing the south. The rain, falling on the escarpment and in the region south of the cliffs, would run toward the south or along the foot of the cliffs until it reached some more important water-channel; the rain falling on the plateau, from the brink of the cliffs backward, would run toward the north, and the waters falling on this upper region would excavate channels for themselves, and, under proper conditions, cañons would be cut. As the cliffs are undermined and this line carried back into the plateau, the area with a southern drainage would be increased, the area with a northern drainage correspondingly diminished, and, when the process had continued for a sufficient length of time, we would find the southern edge of the plateau carried away by this undermining process, until all the heads of the streams were cut off and until the line had reached the cañons.

Gradually, during the progress of erosion, the excavation of the bottom of the cañons would cease, as the supply of water running through them would be cut off, and such cañons would have to be considered as comparatively ancient. Such facts are frequently observed in this cañon and cliff country.

From such considerations, it seems that we may safely conclude that the cliff topography has prevailed in that region for a long time. There are evidences also that there were cañons here before the present cañons were carved. The facts in relation to this matter can be better stated when we come to discuss the geology of the region.

Mr. G. K. Gilbert, a geologist of Lieutenant Wheeler's corps, in a paper communicated to the Philosophical Society of Washington, in 1873, deduced a similar conclusion from an independent series of facts observed in Western Utah. The basin of Great Salt Lake, a portion of what Fremont designated the "Great Basin," has now so dry a climate that its waters gather in its lowest parts and evaporate, and have no outlet to the sea. In a former period, however, there was more rain, the valley was filled with water to its brim, and in place of the Salt Lake Desert, there was a broad and deep fresh lake, discharging its surplus into the Columbia River. The epoch of this lake Mr. Gilbert finds reason to consider identical with the Glacial Epoch, and it was of limited duration. Among its vestiges are deposits of fossiliferous marl, which are conspicuously contrasted with the gravels and sand that now slowly accumulate in the same region, borne by the intermittent streams that descend from the mountains. Where the beds are superposed, the marls testify to a moist climate and the gravels to a climate so dry that the basin was never filled with water. But above the marls are found only scattered and thin deposits of gravel, while below them the gravel-beds are omnipresent and of

great depth, and hence it was reasoned that the arid period that preceded the Glacial Epoch was many times longer than that which has followed it.

Even during the Glacial Epoch, Mr. Gilbert considers that "the Atlantic slope, and the region of the Great Basin, were contrasted in climate, just as now. The general causes that covered the humid East with a mantle of ice, sufficed, in the arid West, only to flood the valleys with fresh water, and send a few ice-streams down the highest mountain-gorges." [1]

Records of More Ancient Lands.—The summit of the Kaibab Plateau is more than 6,000 feet above the river, and I have already mentioned that the summit of the plateau is also the summit of rocks of the Carboniferous Age. These beds are about 3,500 feet in thickness, and beneath them we have 1,000 feet of conformable rocks of undetermined age. This gives us 4,500 feet, from the summit of the plateau down to the non-conformable beds. Still beneath these we have 1,500 feet, so that we have more than 1,500 feet of other rocks exposed in the depths of the Grand Cañon. Standing on some rock, which has fallen from the wall into the river—a rock so large that its top lies above the water—and looking overhead, we see a thousand feet of crystalline schists, with dikes of greenstone, and dikes and beds of granite. Heretofore we have given the general name granite to this group of rocks; still, above them we can see beds of hard, vitreous sandstone of many colors, but chiefly dark red. This group of rocks adds but little more than 500 feet to the height of the walls, and yet the beds are 10,000 feet in thickness. How can this be? The beds themselves are non-conformable with the overlying Carboniferous rocks; that is, the Carboniferous rocks are spread over their upturned edges.

In the figure (p. 672) we have a section of the rocks of the Grand Cañon. *A*, *A*, represents the granite; *a*, *a*, dikes and eruptive beds; *B*, *B*, these non-conformable rocks. It will be seen that the beds incline to the right. The horizontal beds above, *C*, *C*, are rocks of Carboniferous Age, with underlying conformable beds. The distance along the wall marked by the line $x$, $y$, is the only part of its height represented by these rocks, but the beds are inclined, and their thickness must be measured by determining the thickness of each bed. This is done by measuring the several beds along lines normal to the planes of stratification; and, in this manner, we find them to be 10,000 feet in thickness.

Doubtless, at some time before the Carboniferous rocks *C*, *C*, were formed, the beds *B*, *B*, extended off to the left, but between the periods of deposition of the two series, *B*, *B*, and *C*, *C*, there was a period of erosion. The beds themselves are records of the invasion

[1] Bulletin of the Philosophical Society, Washington, forty-sixth meeting, April 26, 1873.

of the sea; the line of separation, the record of a long time when the region was dry land. The events in the history of this intervening time, the period of dry land, one might suppose were all lost. What plants lived here, we cannot learn; what animals roamed over the hills, we know not; and yet there is a history which is not lost, for we find that after these beds were formed as sediments beneath the sea, and still after they had been folded, and the sea had left them, and the rains had fallen on the country long enough to carry out 10,000 feet of rocks, the extension of these beds to the south, which were cut away, and yet before the overlying Carboniferous rocks were formed as sediments of sand and triturated coral-reefs, and ground shells and pulverized bones, some interesting events occurred, the records of which are well preserved. This region of country was fissured, and the rocks displaced so as to form faults, and through the fissures floods of lava were poured, which, on cooling, formed beds of trap or greenstone. This greenstone was doubtless poured out on the dry land, for it bears evidence of being eroded by rains and streams prior to the deposition of the overlying rocks.

Let us go down again, and examine the junction between these red rocks, with their intrusive dikes and overlying beds of greenstone, and the crystalline schists below.

We find these lower rocks to be composed chiefly of metamorphosed sandstones and shales, which have been folded so many times, squeezed, and heated, that their original structure, as sandstones and shales, is greatly obscured, or entirely destroyed, so that they are called metamorphic crystalline schists.

Dame Nature kneaded this batch of dough very thoroughly. After these beds were deposited, after they were folded, and still after they were deeply eroded, they were fractured, and through the fissures came floods of molten granite, which now stands in dikes, or lies in beds, and the metamorphosed sandstones and shales, and the beds of granite, present evidences of erosion subsequent to the periods just mentioned, yet antecedent to the deposition of the non-conformable sandstones.

Here, then, we have evidences of another and more ancient period of erosion, or dry land. Three times has this great region been left high and dry by the ever-shifting sea; three times have the rocks been fractured and faulted; three times have floods of lava been poured up through the crevices; and three times have the clouds gathered over the rocks, and carved out valleys with their storms. The first time was after the deposition of the schists; the second was after the deposition of the red sandstones; the third time is the present time. The plateaus and mountains of the first and second periods have been destroyed or buried; their eventful history is lost; the rivers that ran into the sea are dead, and their waters are now rolling as tides, or coursing in other channels. Were there cañons then? I

think not. The conditions necessary to the formation of cañons are exceptional in the world's history.

We have looked back unnumbered centuries into the past, and seen the time when the schists in the depths of the Grand Cañon were first formed as sedimentary beds beneath the sea; we have seen this long period followed by another of dry land—so long that even hundreds, or perhaps thousands, of feet of beds were washed away by the rains; and, in turn, followed by another period of ocean triumph, so long, that at least 10,000 feet of sandstones were accumulated as sediments, when the sea yielded dominion to the powers of the air, and the region was again dry land. But aërial forces carried away the 10,000 feet of rocks, by a process slow yet unrelenting, until the sea again rolled over the land, and more than 10,000 feet of rocky beds were built over the bottom of the sea; and then again the restless sea retired, and the golden, purple, and black hosts of heaven made missiles of their own misty bodies—balls of hail, flakes of snow, and drops of rain—and when the storm of war came, the new rocks fled to the sea. Now we have cañon-gorges and deeply-eroded valleys, and still the hills are disappearing, the mountains themselves are wasting away, the plateaus are dissolving, and the geologist, in the light of the past history of the earth, makes prophecy of a time when this desolate land of Titanic rocks shall become a valley of many valleys, and yet again the sea will invade the land, and the coral animals build their reefs in the infinitesimal laboratories of life, and lowly beings shall weave nacre-lined shrouds for themselves, and the shrouds shall remain entombed in the bottom of the sea, when the people shall be changed, by the chemistry of life, into new forms; monsters of the deep shall live and die, and their bones be buried in the coral sands. Then other mountains and other hills shall be washed into the Colorado Sea, and coral-reefs, and shales, and bones, and disintegrated mountains, shall be made into beds of rock, for a new land, where new rivers shall flow.

Thus ever the land and sea are changing; old lands are buried, and new lands are born, and with advancing periods new complexities of rock are found; new complexities of life evolved.

## A NEW ANTISEPTIC.

CHEMISTS have long been familiar with the substance known as salicylic acid, and in the text-books most of its properties are described, as also the various modes of preparing it. Its most valuable property, however, namely, its action as an anti-ferment and antiseptic, was discovered only about a year ago, by Prof. Kolbe, of the

University of Leipsic. Salicylic acid exists ready-formed in the flowers of *Spiræa ulmaria* (meadow-sweet), and as methyl-salicylic acid in oil of wintergreen. It is also prepared from indigo and from *salicin*, a substance found in the bark of several species of willow and poplar. But the best mode of preparing it is that proposed by Kolbe and Lautemann, which is thus described by Watts:

Dry carbonic anhydride is passed into warm phenol, with addition of small pieces of sodium. The metal then dissolves, with evolution of hydrogen, and a stiff paste is formed, containing the isomeric salts, salicylate and phenyl-carbonate of sodium, together with unaltered phenol. On acidulating with hydrochloric acid, the phenyl-carbonic acid is decomposed, with evolution of carbonic anhydride, and the salicylic acid which is set free may be separated from the phenol by solution in strong aqueous carbonate of ammonium. The solution, boiled down till it acquires a slight acid reaction, filtered from separated resin, and mixed with hydrochloric acid, yields salicylic acid, to be purified by recrystallization with the aid of animal charcoal.

Reasoning from the fact that salicylic acid can thus be prepared from phenol and carbonic acid, and from the further fact that on the application of heat it again splits up into those two acids, Kolbe was led to inquire whether it possessed the antiseptic properties of phenol. The value of the latter substance as an anti-ferment is well known, but its poisonous properties, as well as its disagreeable smell and acrid taste, render it unsuitable as a means of preserving articles of food, or as a medicinal agent. It was evident, therefore, that if salicylic acid, which is odorless, almost tasteless, and, when taken in small quantities, innocuous, possessed antiseptic properties equal to those of phenol, one of the most urgent wants of modern life would be at once supplied. Experiment proved the conjecture to be correct, and thus many years of theoretical investigation were crowned by practical results of the highest value.

Among the experiments made with this substance we may mention the following: Brewer's yeast (quantity not stated), which causes alcoholic fermentation of sugar, was found to have no effect upon a solution of glucose containing the one-thousandth part of salicylic acid. Half a gramme of the acid suffices to check the fermentation produced by five grammes of beer-yeast, acting on 120 grammes of sugar dissolved in a litre of water. Experiments made by Neubauer show that 100 grammes of salicylic acid suffices to absolutely prevent fermentation in 1,000 litres of *must*, or fresh-pressed juice of grapes. Flour of mustard, which, when mixed with lukewarm water, gives out the pungent oil of mustard, is perfectly odorless when a small quantity of salicylic acid is added to it. So, too, this acid prevents the action of emulsin (the ferment contained in almonds) upon amygdalin, and the conversion of the latter into oil of bitter-almonds. Milk treated with 0.04 per cent. of salicylic acid remained uncoagulated for thirty-six

hours longer than milk not so treated. In like manner a litre of beer, containing one gramme of the acid, and exposed to the air, did not become sour after standing for a considerable time, nor was there the slightest trace of mould. As a means of keeping water sweet on shipboard it is specially valuable.

Eggs immersed for an hour in a solution of salicylic acid were at the end of three months as fresh as at first. Flesh-meat dusted over with the acid keeps its freshness for weeks. When about to be used, the meat may be dipped into water, to remove the acid.

Dr. Thiersch, of the Leipsic Hospital, has used this substance "with very favorable results" in his surgical practice. Kolbe has employed it as a wash for the teeth and mouth, and asserts that it is very effectual in purifying the breath. In a communication published in the *Journal für praktische Chemie*, he says: "As a medicine for internal use, salicylic acid does not seem to have been much employed hitherto, and yet, owing to its antiseptic properties, it is indicated in all diseases of the blood, especially in those which are developed by contagion." Among the diseases likely to yield to this treatment he names scarlatina, diphtheria, measles, small-pox, syphilis, dysentery, typhus, and cholera. Further, he is inclined to think that it might be effectual in dealing with pyæmia and hydrophobia.

Dr. Karl Fontheim, writing to the same journal, says: "This new remedy has been found of very special benefit in treating diphtheria; I have employed it in thirty-two cases; of these none have proved fatal, and the worst cases recovered in eight days." Prof. Zürn, of Leipsic, has employed salicylic acid in veterinary practice, both medical and surgical, and it is his opinion that "for internal and external use in domestic animals, as an antiseptic and destroyer of living contagia, it is destined to occupy as honorable a position in veterinary practice as it does in human medicine."

Kolbe has experimented on his own person, to determine whether or not salicylic acid is injurious to the animal economy. For several days in succession he took daily, in four parts, one half-gramme (solution in water 1:1,000), without the slightest bad effect. After an interval of eight days, he for five successive days took double the former dose, and for two successive days he took one and a half gramme. In the mean time his digestion was entirely normal; there was no feeling of oppression in the stomach, nor did he experience any inconvenience whatever. Other physicians who, at his request, made the same experiments, confirm these results. Still the remedy must not be taken in the form of a powder, for in that shape it attacks the mucous membrane of the mouth and œsophagus; it must be taken in solution.

F. von Heyden, of Dresden, manufactures salicylic acid on a large scale, according to the process of Kolbe and Lautemann. The product is a yellowish-white powder. This is the crude acid, which may be

employed for disinfecting purposes. When intended for preserving articles of food, or for medical or surgical uses, this crude acid must be purified, and then its color is snowy white. Rautert has succeeded in sublimating it completely in a current of superheated steam, thus readily obtaining it pure. Recrystallization from hot distilled water gives it in the form of slender needles an inch long.

## THE MECHANICAL ACTION OF LIGHT.

By WILLIAM CROOKES, F. R. S

SOME experiments illustrating the mechanical action of light, which I have recently exhibited before the Fellows of the Royal Society, having attracted considerable attention, I propose to give here a description of some of the instruments which my researches have enabled me to construct. But, to render the subject more intelligible, it will be necessary to give a brief outline of the researches which I have been carrying on for the last three or four years, so that the reader may see the gradual steps which have led up to the full proof that radiation is a motive power.

The experiments were first suggested by some observations made when weighing heavy pieces of glass apparatus in a chemical balance, inclosed in an iron case from which the air could be exhausted. When the substance weighed was of a temperature higher than that of the surrounding air and the weights, there appeared to be a variation of the force of gravitation. Experiments were thereupon instituted to render the action more sensible and to eliminate sources of error.[1]

My first experiments were performed with apparatus made on the principle of the balance. An exceedingly fine and light arm was delicately suspended in a glass tube by a double-pointed needle; and at the ends were affixed balls of various materials. Among the substances thus experimented on I may mention pith, glass, charcoal, wood, ivory, cork, selenium, platinum, silver, aluminium, magnesium, and various other metals.

The most delicate apparatus for general experiment was made with a straw beam having pith masses at the end. The general appearance of the apparatus is shown in Fig. 1.

*A* is the tube belonging to the Sprengel pump.[2] *B* is the desiccator, full of glass beads moistened with sulphuric acid. *C* is the tube containing the straw balance with pith ends: it is drawn out to a con-

[1] "On the Atomic Weight of Thallium," "Philosophical Transactions," 1873, vol. clxiii., p. 287.

[2] For a full description of this pump, with diagrams, *see* "Philosophical Transactions," 1873, vol. clxiii., p. 295.

tracted neck at the end connected with the pump, so as to readily admit of being sealed off at any stage of the exhaustion. *D* is the pump-gauge, and *E* is the barometer.

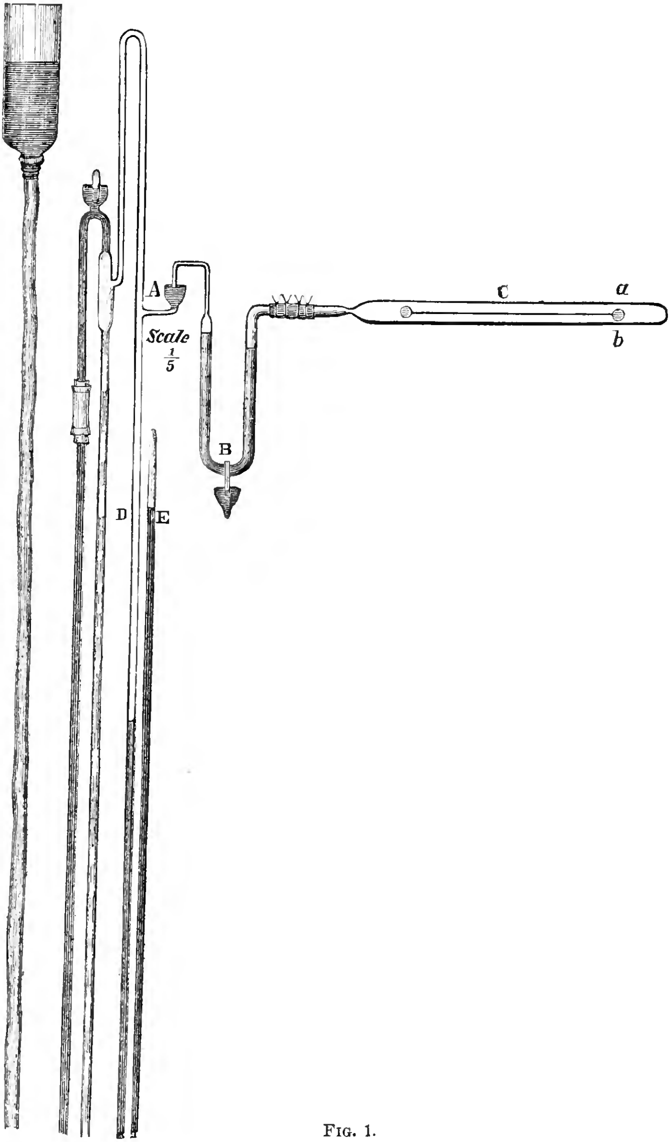



Fig. 1.

The whole being fitted up as here shown, and the apparatus being full of air to begin with, I passed a spirit-flame across the lower part of the tube at *b*, observing the movement by a low-power micrometer: the pith-ball (*a b*) descended slightly, and then immediately rose to

considerably above its original position. It seemed as if the true action of the heat was one of attraction, instantly overcome by ascending currents of air. A hot metal or glass rod and a tube of hot water applied beneath the pith-ball at *b* produced the same effect as the flame; when applied above at *a* they produced a slight rising of the ball. The same effects take place when the hot body is applied to the other end of the balanced beam. In these cases air-currents are sufficient to explain the rising of the ball under the influence of heat.

In order to apply the heat in a more regular manner, a thermometer was inserted in a glass tube, having at its extremity a glass bulb about one and a half inch diameter; it was filled with water and then sealed up (*see* Fig. 2). This was arranged on a revolving stand, so that by means of a cord I could bring it to the desired position without moving the eye from the micrometer. The water was kept heated to 70° C., the temperature of the laboratory being about 15° C.

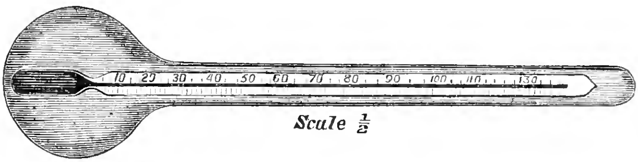



FIG. 2.

The barometer being at 767 millimetres and the gauge at zero, the hot bulb was placed beneath the pith-ball at *b*. The ball rose rapidly. The source of heat was then removed, and as soon as equilibrium was restored I placed the hot-water bulb above the pith-ball at *a*, when it rose again—more slowly, however, than when the heat was applied beneath it.

The pump was then set to work; and when the gauge was 147 millimetres below the barometer, the experiment was tried again: a similar result, only more feeble, was obtained. The exhaustion was continued, stopping the pump from time to time to observe the effect of heat, when it was seen that the effect of the hot body regularly diminished as the rarefaction increased, until, when the gauge was about twelve millimetres below the barometer, the action of the hot body was scarcely noticeable. At ten millimetres below it was still less; while when there was only a difference of seven millimetres between the barometer and the gauge, neither the hot-water bulb, the hot rod, nor the spirit-flame, caused the ball to move in an appreciable degree.

The inference was almost irresistible that the rising of the pith was only due to currents of air, and that at this near approach to a vacuum the residual air was too highly rarefied to have power in its rising to overcome the inertia of the straw beam and the pith-balls. A more

delicate instrument would doubtless show traces of movement at a still nearer approach to a vacuum; but it seemed evident that when the last trace of air had been removed from the tube surrounding the balance—when the balance was suspended in empty space only—the pith-ball would remain motionless, wherever the hot body was applied to it.

I continued exhausting. On next applying heat underneath, the result showed that I was far from having discovered the law governing these phenomena; the pith-ball rose steadily, and without that hesitation which had been observed at lower rarefactions. With the gauge three millimetres below the barometer, the ascension of the pith when a hot body was placed beneath it was equal to what it had been in air of ordinary density; while with the gauge and barometer level its upward movements were not only sharper than they had been in air, but they took place under the influence of far less heat—the finger, for example, instantly repelling the ball to its fullest extent.

To verify these unexpected results, air was gradually let into the apparatus, and observations were taken as the gauge sank. The same effects were produced in inverse order, the point of neutrality being when the gauge was about seven millimetres below a vacuum.

A piece of ice produced exactly the opposite effect to a hot body.

The presence of air having so marked an influence on the action of heat, an apparatus was fitted up in which the source of heat (a platinum spiral rendered incandescent by electricity) was inside the vacuum-tube instead of outside it as before; and the pith-balls of the former apparatus were replaced by brass balls. By careful manipulation and turning the tube round, I could place the equipoised brass ball either over, under, or at the side of the source of heat. With this apparatus I tried many experiments, to ascertain more about the behavior of the balance during the progress of the exhaustion, both below and above the point of no action, and also to ascertain the pressure corresponding with this critical point.

In one experiment, which is described in detail in my paper on this subject before the Royal Society,[1] the pump was worked until the gauge had risen to within five millimetres of the barometric height. On arranging the ball above the spiral, and making contact with the battery, the attraction was still strong, drawing the ball downward a distance of two millimetres. The pump continuing to work, the gauge rose until it was within one millimetre of the barometer. The attraction of the hot spiral for the ball was still evident, drawing it down when placed below it, and up when placed above it. The movement, however, was much less decided than before; and, in spite of previous experience, the inference was very strong that the attraction would gradually diminish until the vacuum was absolute, and that then, and not till then, the neutral point would be reached. Within one milli-

[1] "Philosophical Transactions," 1874, vol. clxiv., p. 501.

metre of a vacuum there appeared to be no room for a change of sign.

The gauge rose until there was only half a millimetre between it and the barometer. The metallic hammering heard when the rarefaction is close upon a vacuum commenced, and the falling mercury only occasionally took down a bubble of air. On turning on the battery-current, there was the faintest possible movement of the brass ball (toward the spiral) in the direction of attraction.

The working of the pump was continued. On next making contact with the battery, no movement could be detected. The red-hot spiral neither attracted nor repelled. I had arrived at the critical point. On looking at the gauge I saw it was level with the barometer.

The pump was now kept at full work for an hour. The gauge did not rise perceptibly, but the metallic hammering sound increased in sharpness, and I could see that a bubble or two of air had been carried down. On igniting the spiral, I saw that the neutral point had been passed. The sign had changed, and the action was one of faint but unmistakable *repulsion*. The pump was still kept going, and an observation was taken, from time to time, during several hours. The repulsion continued to increase. The tubes of the pump were now washed out with oil of vitriol,[1] and the working was continued for an hour.

The action of the incandescent spiral was now found to be energetically *repellent*, whether it was placed above or below the brass ball. The fingers exerted a repellent action, as did also a warm glass rod, a spirit-flame, and a piece of hot copper.

In order to decide once for all whether these actions really were due to air-currents, a form of apparatus was fitted up which—while it would settle the question indisputably—would at the same time be likely to afford information of much interest.

By chemical means I obtained in an apparatus a vacuum so nearly perfect that it would not carry a current from a Ruhmkorff's coil when connected with platinum wires sealed into the tube. In such a vacuum the repulsion by heat was still found to be decided and energetic.

I next tried experiments in which the rays of the sun, and then the different portions of the solar spectrum, were projected on to the delicately-suspended pith-ball balance. *In vacuo* the repulsion by a beam of sunlight is so strong as to cause danger to the apparatus, and resembles that which would be produced by the physical impact of a material body.

A simpler form of the apparatus for exhibiting the phenomena of attraction in air and repulsion in a vacuum consists of a long glass tube, *a b* (Fig. 3), with a globe, *c*, at one end. A light index of pith, *d e*, is suspended in this globe by means of a cocoon fibre.

When the apparatus is full of air at ordinary pressure, a ray of

[1] This can be effected without interfering with the exhaustion.

heat or light falling on one of the extremities of the bar of pith gives a movement indicating attraction. When the apparatus is exhausted until the barometric gauge shows a depression of twelve millimetres below the barometer, neither attraction nor repulsion results when radiant light or heat falls on the pith, but, when the vacuum is as good

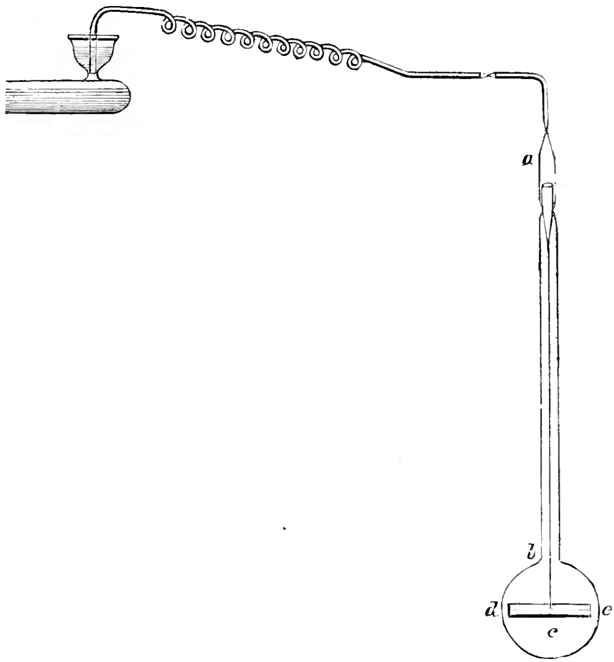



Fig. 3.

as the pump will produce, strong repulsion is shown when radiation is allowed to fall on one end of the index. An apparatus of this kind, constructed with the proper precautions, and sealed off when the vacuum is perfect, is so sensitive to heat that a touch with the finger on a part of the globe near one extremity of the pith will drive the index round over 90°, while it follows a piece of ice as a needle follows a magnet. With a large bulb, very well exhausted, and containing a suspended bar of pith, a somewhat striking effect is produced when a lighted candle is placed about two inches from the globe. The pith-bar commences to oscillate to and fro, the swing gradually increasing in amplitude until the dead-centre is passed over, when several complete revolutions are made. The torsion of the suspending fibre now offers resistance to the revolutions, and the bar commences to turn in the opposite direction. This movement is kept up with great energy and regularity as long as the candle burns.

For more accurate experiments I prefer making the apparatus dif-

ferently. Fig. 4 represents the best form: *a b* is a glass tube, to which is fused at right angles another narrower tube, *c d*; the vertical tube is slightly contracted at *e*, so as to prevent the solid stopper *d*—which just fits the bore of the tube—from falling down. The lower end of the stopper, *d e*, is drawn out to a point; and to this is cemented

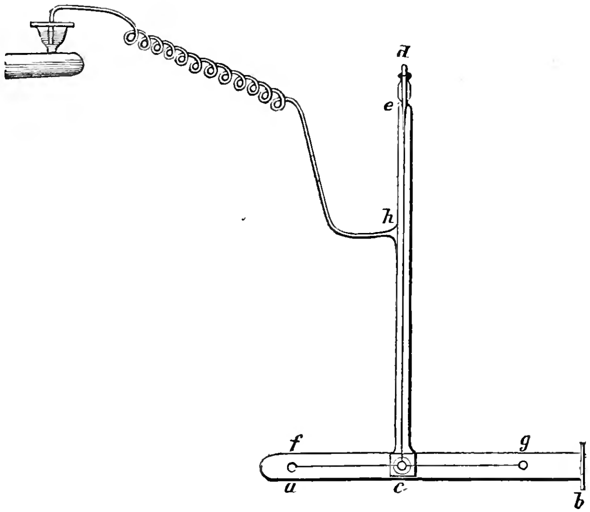



FIG. 4.

a fine glass thread, about 0.001 inch diameter, or less, according to the torsion required.[1]

At the lower end of the glass thread an aluminium stirrup and a concave glass mirror are cemented, the stirrup being so arranged that it will hold a beam, *f g*, having masses of any desired material at the extremities. At *c* in the horizontal tube is a plate-glass window cemented on to the tube. At *b* is also a piece of plate-glass cemented on. Exhaustion is effected through a branch-tube, *h*, projecting from the side of the upright tube. This is sealed by fusion to the spiral tube of the pump. The stopper *d e* and the glass plates *c* and *b* are well fastened with a cement of resin and bees'-wax.

The advantage of a glass-thread suspension is that the beam always comes back to its original position.

An instrument of this sort, perfectly exhausted and then sealed off, is shown at work in Fig. 5. It has pith-plates at the extremities of the torsion-beam. A ray of light from the lamp is thrown on to the central mirror, and thence reflected on to the graduated scale. The approach of a finger to either extremity of the beam causes the

[1] Some of the glass fibres used in these torsion-balances are so fine that when one end is held between the fingers the other portion floats about like a spider's thread, and frequently rises until it takes a vertical position.

luminous index to travel several inches, showing repulsion. A piece of ice brought near causes the spot of light to travel as much in the opposite direction. In order to insure the luminous index coming accurately back to zero, extreme precautions must be taken to keep all extraneous radiation from acting on the torsion-balance. The whole apparatus is closely packed round with a layer of cotton-wool about six inches thick, and outside this is arranged a double row of Winchester quart-bottles, filled with water, spaces only being left for the radiation to fall on the balance and for the index ray of light to get to and from the mirror.

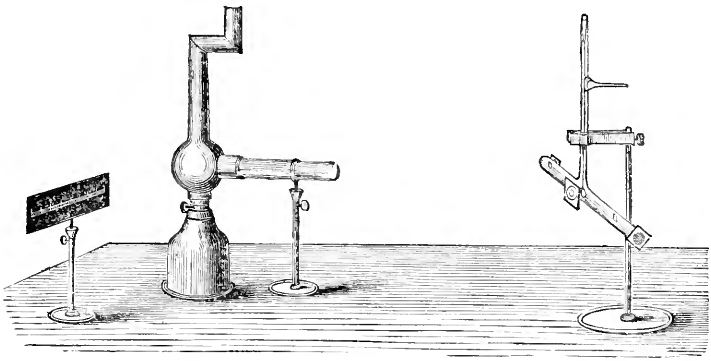


FIG. 5.

However much the results may vary when the vacuum is imperfect, with an apparatus of this kind they always agree among themselves when the residual gas is reduced to the minimum possible; and it is of no consequence what this residual gas is. Thus, starting with the apparatus full of various vapors and gases, such as air, carbonic acid, water, iodine, hydrogen, ammonia, etc., there is not found, at the highest rarefaction, any difference in the results which can be traced to the residual gas. A hydrogen vacuum appears the same as a water or an iodine vacuum.

The neutral point for a thin surface of pith being low, and that for a moderately thick piece of platinum being high, it follows that at a rarefaction intermediate between these two points pith will be repelled, and that platinum will be attracted by the same beam of radiation. This has been proved experimentally. An apparatus showing simultaneous attraction and repulsion by the same ray of light is illustrated in Fig. 6.

The pieces $f\ g$ on the end of one beam consist of platinum-foil exposing a square centimetre of surface, while the extremities $f'\ g'$ on the other beam consist of pith-plates of the same size. A wide beam of radiation thrown in the centre of the tube on to the plates $g\ f'$ causes $g$ to be attracted and $f'$ to be repelled, as shown by the

light reflected from the mirrors, *c c'*. The atmospheric pressure in the apparatus is equal to about forty millimetres of mercury.

In a torsion-apparatus similar to the one shown in Figs. 4 and 5 I have submitted variously-colored disks to the action of the different rays of the spectrum. The most striking results, as yet, have been obtained when the different rays of the spectrum were thrown on white and on black surfaces. The result was to show a decided difference between the actions of light and of radiant heat. At the highest exhaustions dark heat from boiling water acts almost equally on white pith and on pith coated with lamp-black, repelling either with about the same force. The action of the luminous rays, however, is different. These repel the black surface more energetically than they do the white surface, and, consequently, if in such an apparatus as is

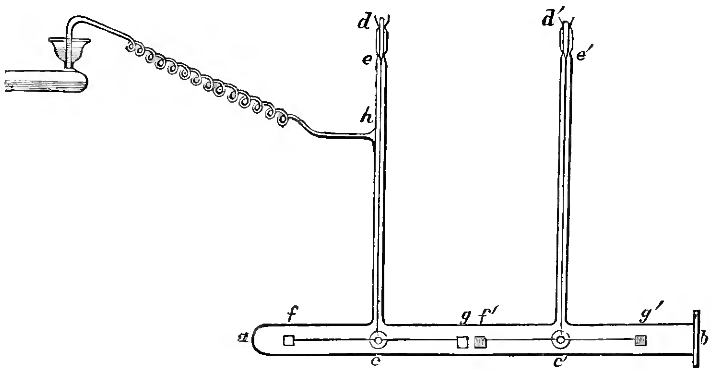


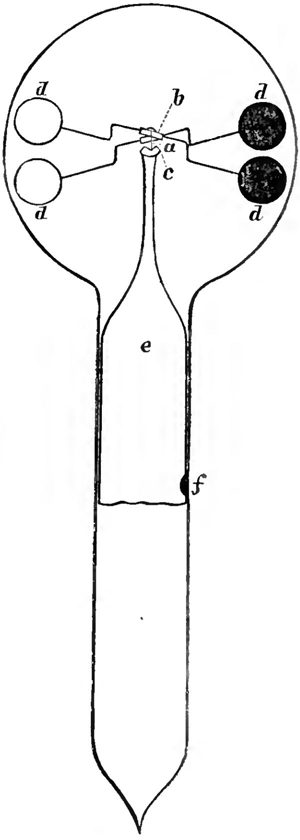

Fig. 6.

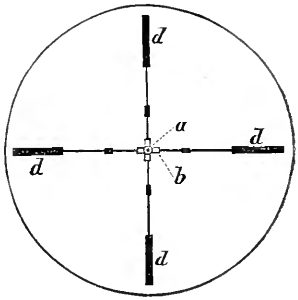
shown at Fig. 4, one disk of pith is white and the other is black, an exposure of both of them to light of the same intensity will cause the torsion-thread to twist round, owing to the difference of repulsion exerted on the black and the white surface. If, in the bulb-apparatus shown in Fig. 3, the halves of the pith-bar are alternately white and lamp-blacked, this differential action will produce rapid rotation in one direction, which keeps up until stopped by the torsion of the suspending fibre.

Taking advantage of this fact I have constructed an instrument which I have called the Radiometer, shown in section and plan at Figs. 7 and 8. It consists of four arms, of some light material, suspended on a hard steel point resting in a jewel-cup, so that the arms are able to revolve horizontally upon the centre pivot, in the same manner as the arms of Dr. Robinson's anemometer revolve. To the extremity of each arm is fastened a thin disk of pith, white on one side and lamp-blacked on the other, the black surfaces of all the disks facing the same way. The whole is inclosed in a thin glass globe,

which is then exhausted to the highest attainable point and hermetically sealed.

The arms of this instrument rotate with more or less velocity under the action of radiation, the rapidity of revolution being directly proportional to the intensity of the incident rays. Placed in the sun,




FIGS. 7 and 8.—*a*, a very fine needle-point; *b*, two pieces of straw; *c*, jewel-cup; *d*, *d*, *d*, *d*, four pith-disks, blackened on one side. The arms between the straw in the centre and the disks are bent glass-fibres; *e*, glass support holding cup; *f*, cement to keep the support *c* in its place.

or exposed to the light of burning magnesium, the rapidity is so great that the separate disks are lost in a circle of light. Exposed to a candle twenty inches off another instrument gave one revolution in 182 seconds; with the same candle placed at a distance of ten inches off the result is one revolution in 45 seconds; and at five inches off one revolution was given in 11 seconds. Thus it is seen that the mechanical action of radiation is inversely proportional to the square of the distance. At the same distance two candles give exactly double, and three candles give three times the velocity given by one candle, and

so on up to twenty-four candles. A small radiometer was found to revolve at the velocities shown in the following table, when exposed to the radiation of a standard candle five inches off:

*Time required for One Revolution.*

| Source of Radiation. | Time in Seconds. |
|---|---|
| 1 candle, 5 inches off, behind green glass | 40 |
| " 5 " " blue " | 38 |
| " 5 " " purple " | 28 |
| " 5 " " orange " | 26 |
| " 5 " " yellow " | 21 |
| " 5 " " light-red " | 20 |

In diffused daylight the velocity was one revolution in from 1.7 seconds to 2.3 seconds, according to the intensity of the incident rays. In full sunshine, at 10 A. M., it revolved once in 0.3 second, and at 2 P. M. once in 0.25 second.

When heat is cut off by allowing the radiation to pass through a thick plate of alum, the velocity of rotation is somewhat slower, and when only dark heat is allowed to fall on the arms (as from a vessel of boiling water) no rotation whatever is produced.

In all respects, therefore, it is seen that the radiometer gives indications in strict accordance with theory.

Several radiometers, of various constructions as regards details, but all depending on the above-named discovery, have been exhibited at the Royal Society, where their novelty and unexpected indications excited a considerable amount of interest.

This form of instrument is of too recent a construction for me to be able to do more than draw brief attention to a few of the many uses for which it is applicable.

By timing the revolutions of the instrument when exposed direct to a source of light—a candle, for instance—the total radiation is measured. If a screen of alum is now interposed, the influence of heat is almost entirely cut off, the velocity becomes proportionately less, and the instrument becomes a photometer. By its means photometry becomes much simplified; flames the most diverse may readily be compared between themselves or with other sources of light; a "standard candle" can now be defined as one which at $x$ inches off causes the radiometer to perform $y$ revolutions per minute, the values of $x$ and $y$ having previously been determined by comparison with some ascertained standard; and the statement that a gas-light is equal to so many candles may, with more accuracy, be replaced by saying that it produces so many revolutions.

To photographers the radiometer will be invaluable. As it will revolve behind the orange-colored glass used for admitting light into the so-called dark-room, it is only necessary to place one of these instruments in the window to enable the operator to see whether the

light entering his room is likely to injure the sensitive surfaces there exposed; thus, having ascertained by experience that his plates are fogged, or his paper injured, when the revolutions exceed, say, ten a minute, he will take care to draw down an extra blind when the revolutions approach that number. Still more useful will the radiometer be in the photographic gallery. Placing an instrument near the sitter at the commencement of the day's operations, it is found that, to obtain a good negative, the lens must be uncovered—not for a particular number of seconds—but during the time required for the radiometer to make, say, twenty revolutions. For the remainder of the day, therefore, assuming his chemicals not to vary, the operator need not trouble himself about the variation of light; all he has to do is to watch the radiometer and expose for twenty revolutions, and his negatives will be of the same quality,[1] although at one time it may have taken five minutes, and at another not ten seconds, to perform the allotted number.

I have long been experimenting in the endeavor to trace some connection between the movements of attraction and repulsion above alluded to and the action of gravitation in Cavendish's celebrated experiment. The investigation is not sufficiently advanced to justify further details, but I will give here an outline of one of the results.

I find that a heavy metallic mass, when brought near a delicately-suspended light ball, attracts or repels it under the following circumstances:

I. *When the ball is in air of ordinary density.*
 *a.* If the mass is *colder* than the ball, it *repels* the ball.
 *b.* If the mass is *hotter* than the ball, it *attracts* the ball.

II. *When the ball is in a vacuum.*
 *a.* If the mass is *colder* than the ball, it *attracts* the ball.
 *b.* If the mass is *hotter* than the ball, it *repels* the ball.

The density of the medium surrounding the ball, the material of which the ball is made, and a very slight difference between the temperatures of the mass and the ball, exert so strong an influence over the attractive and repulsive force, and it has been so difficult for me to eliminate all interfering actions of temperature, electricity, etc., that I have not yet been able to get distinct evidence of an independent force (not being of the nature of heat or light) urging the ball and the mass together.

Experiment has, however, shown me that, while the action is in one direction in dense air, and in the opposite direction in a vacuum, there is (as I have already pointed out in the experiments described in the commencement of this paper) an intermediate pressure at which differences of temperature appear to exert little or no interfering ac-

[1] In this brief sketch I omit reference to the occasions in which the ultra-violet rays diminish in a greater proportion than the other rays.

tion. By experimenting at this critical pressure, and at the same time taking all the precautions which experience shows are necessary, it would seem that such an action as was obtained by Cavendish, Reich, and Baily, should be rendered evident.

It is not unlikely that in the experiments here recorded may be found the key of some as yet unsolved problems in celestial mechanics. In the sun's radiation passing through the *quasi* vacuum of space we have the radial repulsive force, possessing successive propagation, required to account for the changes of form in the lighter matter of comets and nebulæ, and we may learn by that action, which is rapid and apparently fitful, to find the cause in those rapid bursts which take place in the central body of our system; but until we measure the force more exactly we shall be unable to say how much influence it may have in keeping the heavenly bodies at their respective distances.

So far as repulsion is concerned, we may argue from small things to great, from pieces of pith up to heavenly bodies; and we find that the repulsion shown between a cold and warm body will equally prevail, when for melting ice is substituted the cold surface of our atmospheric sea in space, for a lump of pith a celestial sphere, and for an artificial vacuum a stellar void.

Throughout the course of these investigations I have endeavored to remain unfettered by the hasty adoption of a theory, which, in the early stages of an inquiry, must almost of necessity be erroneous. Some minds are so constituted that they seem impelled to form a theory on the slightest experimental basis. There is then great danger of their becoming advocates, and unconsciously favoring facts which seem to prove their preconceived ideas, and neglecting others which might oppose their views. This is unfortunate, for the mind should always be free to exercise the judicial function, and give impartial weight to every phenomenon which is brought it. *Any* theory will account for *some* facts; but only the true explanation will satisfy *all* the conditions of the problem, and this cannot be said of any theory which has yet come to my mind.

My object at present is to ascertain facts, varying the conditions of each experiment so as to find out what are the necessary and what the accidental accompaniments of the phenomena. By working steadily in this manner, letting each group of experiments point out the direction for the next group, and following up as closely as possible, not only the main line of research, but also the little by-lanes which often lead to the most valuable results, after a time the facts will group themselves together and tell their own tale; the conditions under which the phenomena invariably occur will give the laws; and the theory will follow without much difficulty. The eloquent language of Sir Humphry Davy contains valuable advice, although in terms somewhat exaggerated. He says: "When I consider the va-

riety of theories which may be formed on the slender foundation of one or two facts, I am convinced that it is the business of the true philosopher to avoid them altogether. It is more laborious to accumulate facts than to reason concerning them; but one good experiment is of more value than the ingenuity of a brain like Newton's."—*Quarterly Journal of Science.*

## THE CAUSE OF THE LIGHT OF FLAMES.

By W. STEIN.

THE correctness of the old and well-founded conception that the light of flame is caused by incandescent carbon-molecules, has been disputed by Dr. Frankland, who contends and tries to prove that it is derived from hydrocarbon-vapors. It is evident that the old theory would have to give place to the new doctrine as soon as the untenability of the former and the correctness of the latter are proved. But neither the one nor the other has, I think, yet been done. Prof. Frankland can, therefore, only be pleased if the present paper subjects the *pros* and *cons* of the new and old theory to an impartial examination.

As proof of his ideas he mentions that the soot deposited on a cool surface, when introduced into a flame, does not consist of pure carbon, but that it contains also hydrogen; that, in fact, it seems nothing else than a collection of the densest light-giving hydrocarbons, whose vapors condense on the cold surface.

Against this we may mention that not only do the heavy hydrocarbons, but even marsh-gas, split up at high temperatures on exclusion of atmospheric air; and as the hydrocarbons, whose vapors are supposed to cause the luminosity of the flame, are precisely under such conditions before they come into contact with the air, it cannot be doubted that they suffer decomposition into carbon and hydrogen in the luminous portion of the flame. It is of little importance whether the eliminated carbon is chemically pure, or whether it contains still a hydrogen compound; the important question is this, Is the soot held by the flame in the shape of vapor or in the solid form? If the soot was nothing but a conglomeration of the densest light-giving hydrocarbons, whose vapors condense on a cool body, then, when sufficiently highly heated by exclusion of air, it ought to reassume vapor-form. This is, however, not the case, as every one will find who tries the experiment.

Its chemical composition is just as little favorable to Frankland's view. It ought, presumedly, to vary according to the lighting material from which it was derived—nay, even according to the place of

the flame wherefrom it was deposited. It is well known that the temperature of the flame varies in various places, and Magnus's experiments have proved that from heavy hydrocarbons at a less high temperature a hydrogenous tarry product besides hydrocarbon is also eliminated. The soot, whose analysis I give, was obtained from a bat's-wing burner by allowing a small silver basin, filled with water, to dip for about two or three minutes in the flame. Benzine removed traces of a solid yellow body, but the small amount of it prevented its being further investigated. Alcohol, and alcoholic solution of caustic potash, and dilute sulphuric acid, dissolved nothing.

After being carefully and repeatedly washed with boiling water and dried at 130°, 0.206 yielded: Carbonic acid, 0.6985; water, 0.0195; ash, 0.0020—which amounts in 100 parts to.

| | Containing Ash. | Free from Ash. |
|---|---|---|
| Carbon | 96.446 | 97.390 |
| Hydrogen | 1.051 | 1.061 |
| Ash | 0.970 | ..... |
| Oxygen | 1.533 | 1.533 |

I attribute the presence of oxygen to a small amount of water, which, even at 130°, was still retained, and this, when deducted, gives the composition of 100 parts of soot free from water and ash as consisting of carbon, 99.095; hydrogen, 0.905.

This analysis is in accordance with the chemical composition of the soot of the flame, and with the well-known behavior of heated hydrocarbons.

2. "How could the light of a flame be as transparent as in reality it is, if it was filled with solid carbon-particles?" asks Dr. Frankland.

In reply to this, it must be admitted that one is able to read the writing held behind the flame of a bat's-wing burner. It is, however, easily observable that the flame is more transparent in the lower non-luminous portion. The reading becomes also more difficult through a flame of greater thickness, and impossible through the flame of a candle or petroleum-burner. If, as is proved hereby, the transparency of a flame is only very limited, it may also be remembered that one can also read the same writing through media which are known to be filled with solid particles. The fact that solid bodies are by preference apt to become light-radiating is not at all changed by this, and thus far it is demonstrated only that there can be but one solid body to which the luminosity of flame can be attributed. If we consider, therefore, all the facts, we can draw only one conclusion, namely, that the light of our illuminating flame comes from incandescent carbon-molecules, and that the old view is still to be retained.

Experience teaches that, for the artificial production of light, a high temperature is requisite before all things. Temperature is, however, that part of the total heat of a body which influences the surrounding

parts, or the surplus of atomic movement which is not consumed by its inner work. A high temperature means, therefore, a great excess of such movement, which again is identical with a greater number of momentary vibrations. In fact, the movement of light and the movement of heat differ essentially by regularity (*rhythmen*), and greater movement of heat passes, therefore, presumedly into movement of light, if it has reached the lowest number of vibrations for light, namely, those of red light. If, after a greater and greater rising of temperature up to its highest possible degree, the rapidity of movement increases more and more, we observe, besides the red light, first, yellow light, forming orange with the former; later, we meet also blue light, which, however, in most cases, only serves to form white light with the red and yellow, and which is only predominant in very rare cases, as observed by Deville. Under ordinary circumstances, we only get a yellow or red light containing more or less white. The more white it contains the greater is, naturally, its effect of light; and, as white only appears at the highest temperatures, it becomes evident that the temperature of a flame does not exert a secondary influence on its luminosity, but is its principal factor. The second factor is the eliminated carbon, the molecules of which radiate the light. The luminosity of two flames of the same temperature corresponds, therefore, to the number of its carbon-molecules, and "luminosity in general equal to the product of the radiating molecules and their temperatures" for illuminating purposes, it may be presumed that the latter should amount to at least 1,000°.

The above-mentioned phenomena of light may easily be observed on solid bodies if heated. They are not observable on gases as long as they expand unhindered. It would, however, be wrong to attribute this negative behavior to the circumstance alone that, by the unhindered expansion, the amount of the added or produced heat was changed into power. This is contradicted by the high temperature which, among others, the non-luminous explosive gas-flame (*Knallgas*) possesses. Besides, it is also observed that platinum wire becomes incandescent in every possible non-luminous flame, even in a flame produced by nitrogen on coal-gas, if the requisite temperature to change heat into light is present.

If we may conclude from this that the atoms of gases may be brought into light-vibrations without becoming luminous, then we possess bodies which conduct the light (the gases), and others which radiate light (the solid bodies), just as we have conductors of electricity and idio-electrical bodies.

An explanation of this difference is offered when light is considered as atomic movement. Its effect to the eye is then the product of quantity and velocity.

In a given space we find a much larger number of vibrating atoms if filled with solid matter than if filled with gas. The waves of light

of solid bodies must, therefore, be much denser than those of gases, and exert also a more intense effect on the nerves of our eyes. "Light-conductors" differ, therefore, from "light-radiators" by the lesser density of their waves of light; for which reason they cannot, under ordinary circumstances, form "optical molecules," as I expressed on another occasion. How powerfully the condensation of the waves of light affects the eye is shown by the effect of collecting lenses.

The minimum of density which a body must possess to become light-radiating—that is, to become self-luminous to the eye, or to appear a source of light—is just now not known; but one sees, if this view is correct, the possibility of even vapors or dense gases becoming luminous, as Frankland tried to prove. The results of his experiments might even serve as foundation for the lowest limit of density, if it were not so very difficult, nay, even just now impossible, to make such an experiment in a manner so as to exclude every doubt about the assisting influence of solid bodies.—*English Mechanic.*

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# MENTAL DISCIPLINE IN EDUCATION.

By A. G. MERWIN.

I THINK it is safe to assume, on the one hand, that all, or nearly all, mental discipline is of value; and, on the other, that all, or nearly all, knowledge is of value. It will also be conceded that a life spent in disciplining the mind, while the mind so disciplined is never employed in the direction of utility, is a life wasted. It seems equally true that utility, when so narrowed as to relate only to the outward trappings of the human being, is not real utility.

By mental discipline we mean nothing more than habit of mental action. The disciplined mind does not differ in kind from the undisciplined any more than the strength of a man differs in kind from the strength of a child. It is evident that the best mental discipline must be that which prepares the mind to grasp and direct the facts, realities, and influences, on which human well-being depends.

It is thought that there is study which gives mental power or discipline, while it results in little useful knowledge. By a method of study the mind is to be developed into an intellectual Samson, but a blind Samson; and it is hoped and believed that a mind só trained will do something better than to involve itself and others in a common ruin. That is, it is assumed that a habit of thought which does not lead to useful knowledge in school, is the habit of thought which will lead to useful knowledge in common affairs of life.

The study of a dead language is supposed to give this mental discipline. Such study has almost nothing to do with present realities.

It trains the mind to look, not so much at the thought as at the manner of expressing the thought. It deals with the tools of thought rather than the thought itself. For years the mind is habituated to work upon those things which must be discarded as soon as school-life is ended; and this is called education. It is not to be denied that such discipline is better than no discipline. It is conceded that such discipline does aid the student in the use of language. But of what value is a discipline which, while it gives power or facility in the use of language, gives little power to investigate those things for which language was made?

Language is the implement of thought, and it would seem that no study of this implement can give the best training for studying the thought itself, or the reality that lies back of the thought. It is probable that the highest efforts of the mind, those efforts in which new truths have flashed out, then vanished, then returned again, until the investigator has finally made them his own, have been made without the aid of language. Language is a medium between man and man, not necessarily between man and Nature. Thoughts which come to us through language must come to us at second-hand. Language, being the medium of thought, cannot precede thought.

Not that the study of language, when pursued in relation to the thought, is of little value; but the folly is in the prolonged study of a language which, with rare exceptions, can never be a highway of knowledge nor a medium of thought. What is the value of words? Words mean the same to those persons only who have had the same experiences. Words do not convey ideas; they suggest them. When a word is spoken, the hearer is at first conscious of sound. If he has been accustomed to associate the spoken word with some idea, the mind instantly represents the idea. If the experience of both speaker and hearer has been the same, the word has the same meaning to each. In the mind of the speaker the idea suggests the word; in the mind of the hearer, the word suggests the idea. No word ever explains any sensation, pleasant or painful, to one who has never felt the sensation. By aid of the imagination we may, to an extent, give meaning to language that does not directly appeal to experience; but the imagination can do nothing more than recombine materials that have been furnished by experience, so that directly or indirectly words derive their meaning from experience; and words have a common meaning because they suggest ideas of a common experience.

It seems to follow that the real value of language must depend upon the amount of knowledge attained. To make the study of language the principal means to an education appears as irrational as to gather stores of the implements of husbandry in the midst of a desert waste—as irrational as to expect to make a skilled mechanic by setting him to study the tools of his trade. Much more irrational does this appear when the language is one in which the mind never does

its work, and which contains at best but the literature, philosophy, and fables of a past age.

I do not mean to disparage language as a means of influencing action and recording thought; but why spend years in the study of languages which we never use to influence action or record thought, under the plea that this study disciplines the mind for useful work? Can useless work produce useful habits? It must not be forgotten, however, that the power of language is greatest where there is least knowledge. It is not difficult to show that the influence of oratory declines as intelligence increases. Men seldom engage in oratory where positive knowledge leaves no play for the imagination. Indeed, science is constantly devising plans to avoid the verbiage of ordinary statement; hence the mathematics. The same general truth appears in the proverb, "A word to the wise." The very word "demagogue" is a warning that we should beware of the specious arts of the orator. Language presupposes thought; a community of language presupposes a community of thought and experience. While correct thinking may exist without correct speaking, it needs but the observation of every day to show that correct and truthful speaking never can exist without correct thinking.

It is pertinent to inquire here by what discipline society has progressed toward the most excellent things. Undoubtedly by the discipline of experience, or it might be called the discipline of environments. Men have not marked out the course of human progress, nor have they, to any considerable extent, been able to forecast it. Two thousand years ago, who would have believed that the northern barbarians would surpass Greece and Rome?

We cannot go back to the ultimate cause, and tell why one class of the human family should progress and another retrograde or remain stationary. We may point out some of the conditions of progress; but the germ of that progress we do not know. We may believe that the best organized and most intelligent communities, by resulting strength, overcome the more poorly organized and less intelligent. We still ask, How came these communities better organized? Why did not this organization occur a thousand years earlier or a thousand years later? We reply, the conditions were not favorable. What do we mean when we say the conditions were not favorable? We mean that there is a certain correspondence or relation between human activities and outlying natural forces. These correspondences and relations are the problems of progress. As yet, we can do little toward their solution.

This much we observe, that in all progress discipline has not been an end but an incident of study. The discipline was attained by man in studying his environments and in altering his relation to those environments. Further, men attained a comparatively high state of mental discipline before schools existed at all.

Again, schools and education, technically so called, are not the antecedent but the consequent of progress. The men who have been most successful in penetrating the secrets of Nature and solving the problems of society have been in advance of any school. The education of these men has not been for mental discipline; they have studied to find the truth, and an incident of that study has been discipline. Whence came that discipline which rendered schools possible? Not from disciplinary studies, certainly. It came in the study of surrounding conditions, with the view to bring those conditions into conformity with what was deemed personal or social well-being. Mental discipline had then the same relation to human activity that it has now. Until schools were created, all study was in the direction of real or apparent utility; all study outside of the schools is at present for knowledge or utility.

That is, the law of education has been and is now, that mental discipline is the incident and not the end of study. Hence the conclusion, study what is most useful, and the resulting discipline will be most valuable.

We see the same truth in another aspect when we observe that the highest mental and physical power is attained in efforts to discover, measure, and control the forces around us. A language is never so easily or so well learned as when our personal comfort depends upon its use. The hand and eye of the hunter are never so thoroughly disciplined as when he knows that at any moment his life may depend on the accuracy of his aim. The mathematics have been invented to measure the relations of things in common life, or to investigate the less apparent relations.

I cannot forbear here to point out, further, that the truth in regard to mental discipline appears to be a universal truth or law of human activity, perhaps of all activity. Discipline is an incidental result of right exercise. In accordance with this truth are developed and disciplined the religious, intellectual, physical, social—indeed, every faculty and capacity within us. This law recognized, and science and philosophy will force us to accept the best truths of religion—those truths which take man out of himself, make him forgetful of himself, and teach him that he does most for himself who does most for others. Upon such a general truth appears to rest the proposition that we should study for utility—for utility in its widest and best sense—and not for discipline. In the light of this truth we recognize the dead languages—all languages—the mathematics, as but the means, the machinery of an education. Resting on experience, they direct us to new experience. These are the glass through which we may see something of ourselves and the universe. Why waste half our lives in studying the glass under pretense of disciplining our eyes, when our eyes would be better disciplined by studying Nature beyond? Better still to break through all barriers, and study things them-

selves, using the records of other men's experience as we may need them.

Again, mental discipline is mental habit. How do we form habits that are desirable? Not by seeking some course of activity that shall create the habit, but by trying to do something that is desirable. Useful habits are incidental results of doing useful work. The mechanic does not use extra care that he may form habits of accuracy, but that he may produce better work. The astronomer does not make his observations with the view of forming habits, but to learn the phenomena of the heavens; and if he be called upon to observe some phenomenon that occurs but once in a lifetime, he will hardly think of seeking that special discipline which the observation may require by studying the conjugation of the Greek verb.

I think we meet this fact everywhere out of the schools, that discipline is not sought as an end. The idea of discipline for its own sake was asceticism in religion. Men sought moral excellence by retiring from the world, and contemplating the things within them. The same idea of discipline led men to look for knowledge within themselves, instead of seeking it by observing things around them. But the system failed in religion and morals, as it failed in discovering truth and educating the intellect. We see why it must fail; it wastes the energies of the individual in acting upon his own powers. What is progress in its last analysis? Is it not change of relation? We are superior to our savage ancestors, because our relations to society and the forces of Nature differ from theirs. What is knowledge but a mental accumulation of true relations? What is reason but the power to compare relations, and what is wisdom but the ability to perceive true relations, and direct our actions in accordance with them? Discipline, habit, and character, appear to be activity crystallized in seeking adaptation to our environments. What is the truth that stands out in relief? Clearly, that character, habit, and discipline, are the reflex upon ourselves of activity, moral, mental, or physical. Whence it seems to follow that useless or vicious activity will appear as useless or vicious character and discipline. On the other hand, we may be sure that the study of those things which it is most important we should know, and the activities which it is most important we should pursue, will give the best discipline, the most valuable habits, and the most excellent character.

The conclusion appears to be that mental discipline is an incident of right education, never an end.

The real educational question is, not of the value of discipline, but of the relative values of the different kinds of knowledge. When we learn what knowledge is most valuable, the habit or discipline incidentally acquired in seeking that knowledge will, no doubt, be the discipline which will aid most in seeking and applying other valuable knowledge throughout the whole course of life.

# THE COLORADO POTATO-BEETLE.

By Prof. C. V. RILEY.

FEW insects have done more serious injury, or attracted greater attention, than this, even in America, where insect depredations attain a magnitude scarcely dreamed of in this country. Feeding originally on the wild *Solanumr ostratum* in the Rocky Mountain regions of Colorado and other Territories, it fell upon the cultivated potato as soon as civilized man began to grow this esculent within its reach. With large fields of palatable food, instead of scattered plants of the wild *Solanum*, to work upon, it multiplied at a marvelous rate, and began to spread from its native home toward the East. Reaching a point 100 miles west of Omaha, Nebraska, in 1859, its progress has been carefully recorded each year since, until last year it reached the Atlantic coast at a number of different points in Connecticut, New Jersey, New York, Pennsylvania, Delaware, Maryland, and Virginia. The present year we hear of it being still more numerous on the Atlantic coast, and of its swarming around New York City, and covering the nets of fishermen. It has thus, in sixteen years, spread over 360 geographical miles, in a direct line; and, if we consider the territory

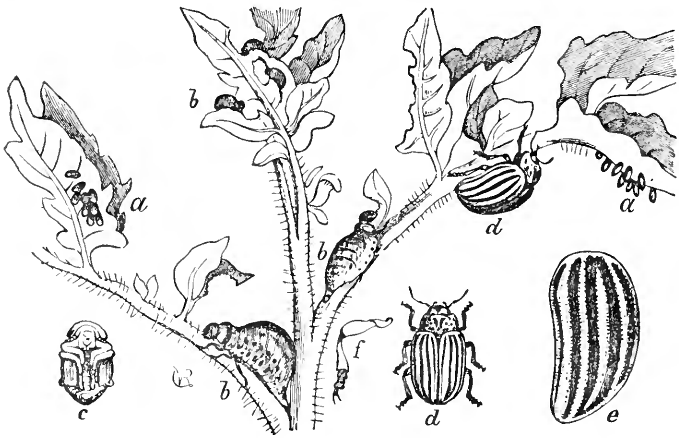



Fig. 1.—Colorado Potato-Beetle.
*a*, *a*, eggs; *b*, *b*, *b*, larvæ of different sizes; *c*, pupa; *d*, *d*, beetle; *e*, left-wing cover magnified to show lines and punctures; *f*, leg enlarged. Colors: of egg, orange; of larvæ, Venetian-red; of beetle, black and yellow.

actually invaded, which includes the States of Kansas, Nebraska, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Indiana, Kentucky, Michigan, Ohio, Ontario (Canada), New York, Vermont, Massachusetts, Pennsylvania, Maryland, and Virginia, it has overrun an area of 800,000 square miles. The natural history of the species was first

made known by me in 1863. The beetle hibernates either beneath the ground or beneath any other shelter that it can obtain. Early in spring it issues from its winter quarters, and may be seen flying about, on sunny days, long before there are any potato-tops for it to devour. In flight it presents a very pretty appearance, its gauzy, rose-colored under-wings contrasting agreeably with the striped yellow and black elytra or wing-covers. The sexes pair, and, as soon as the potato haulms push out of the ground, these beetles break their long winter fast, sometimes even working their way down toward the sprout before it is fairly out of the earth. The eggs, which are orange-yellow, are laid in small clusters on the under sides of the leaves, and the same female continues to thus lay at short intervals for a period of over forty days, until the number laid by a single specimen may aggregate from 500 to over 1,000. There are, in the latitude of St. Louis, three broods each year; but, from the fact that a single female continues to deposit as above described, and from the irregularity of larval development, the insect may be found in all stages throughout the summer months. In from thirty to forty days from the time the egg is deposited, the insect hatching from it goes through all its transformations and become a beetle, the pupa state being assumed underground. The prolificacy of the species may be imagined when it is remembered that the progeny of a single female may exceed a hundred millions in the course of a single season! The beetle feeds as well as the larva, though not so voraciously. Its attacks are principally confined to plants of the family *Solanaceæ*, and it is particularly fond of those belonging to the genus *Solanum*. Yet I have recorded many

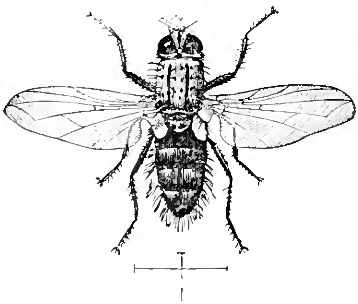


Fig. 2.—Lydella Doryphoræ; Parasite of Doryphora. Colors, Silver-gray and Black.

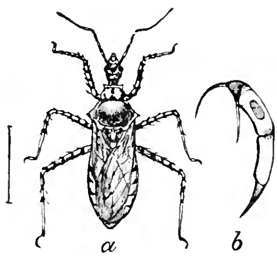



Fig. 3.—Many-banded Robber; with Beak enlarged at Side (*b*). Colors, Pale Yellow and Black. Preys on Doryphora.

instances of its acquiring new habits in its march to the Atlantic, and of its feeding, when hard pushed, on plants of other families. There are various means of destroying the insect, and in the earlier invaded territory of the States, though it continues its ravages, thereby making the cultivation of potatoes more laborious, and increasing their market price, yet it is no longer dreaded as it at first was, for the rea-

son that it is controlled with comparative ease. The natural enemies of the species are encouraged by the intelligent cultivator, and poultry may be taught to feed upon it. Of over twoscore predaceous and parasitic species of its own class which I have enumerated, those herewith figured may be considered the most important. The only true parasite is a species of Tachina-fly (*Lydella doryphoræ*, Riley), somewhat resembling a house-fly, which fastens its eggs to the *doryphora* larva. From these eggs hatch maggots, which feed upon the fatty portions of the said larva, which, after entering the ground, succumbs to its enemy, and, instead of eventually giving forth a beetle, as it naturally should do, gives forth, instead, the Tachina-flies. A number of different lady-birds (*Coccinellidæ*), of which the convergent lady-bird is the most common, devour the eggs of the *doryphora*. Of true bugs the spined soldier-bug (*Arma spinosa*, Dallas) is the most effective, though several other rapacious species assist it, all of them piercing and sucking out the juices of their prey. Of artificial remedies there are various mechanical contrivances for knocking the insects off the haulm and catching them—some such even being worked by horse-power. The sun is, also, so hot in some of the Mississippi Valley States that the larvæ are roasted to death if shaken from the haulm on to the hot soil at mid-day. The remedy of all others, however, and the one universally employed, is Paris-green, which is used either in the form of a powder, or in that of a liquid, being combined in the former case with from twenty-five to thirty parts of some dilutent, as flour-middlings, plaster, etc., and in the latter with one tablespoonful of pure green stirred into an ordinary bucketful or about three gallons of water. Enormous quantities of the poison have thus been used in America, especially since it has proved a perfect remedy for the cotton-worm in the Southern States as well as for the potato-beetle in question. Cautiously and judiciously used it proves cheap and effective, and a large experience goes to show that no ill effects follow such use of it. There is a very closely-allied species, the *Doryphora juncta* of Germar, called the bogus Colorado potato-beetle, which, very naturally, has often been confounded with, and mistaken for, the genuine depredator. It differs, however, in the eggs being paler; in the larva being paler, and in having but one row of black dots on each side instead of two; and in the beetle having the second and third black lines of the elytra (counting from the outside) joined, instead of the third and fourth; in the punctures of said elytra being more regular and distinct, and in the legs having pale instead of dark tarsi, and a spot on the thighs. Singularly enough, this species, though it feeds and thrives on *Solanum Carolinense*, will not touch the cultivated potato, and is, therefore, perfectly harmless to man.

The English reader is more particularly interested in this insect, because of its possible introduction into Europe; and on the subject of its introduction I cannot do better than quote some passages from

my seventh report: "Those who have watched the gradual spread of this potato-beetle during the past seventeen or eighteen years from its native Rocky Mountain home to the Atlantic, and who have seen how lakes, instead of hindering its march into Canada, really accelerated that march, can have no doubt that there is danger of its being carried to Europe. Yet I must repeat the opinion expressed a year ago—and which has been very generally coincided in by all who have any familiarity with the insect's economy—that if it ever gets to Europe it will most likely be carried there in the perfect beetle state on some vessel plying between the two continents. While the beetle, especially in the non-growing season, will live for months without food, the larva would perish in a few days without fresh potato-tops, and would, I believe, starve to death in the midst of a barrel of potatoes, even if it could get there without being crushed; for, while it so voraciously devours the leaves, it will not touch the tubers. The eggs, which are quite soft and easily crushed, could, of course, only be carried over on the haulm or on the living plant; and while there is a bare possibility of the insect's transmission in this way, there is little probability of it, since the plants are not objects of commercial exchange, and the haulm, on account of its liability to rot, is not, so far as I can learn, used to any extent in packing. Besides, potatoes are mostly exported during that part of the year when there are neither eggs, larvæ, nor potato haulm in existence in the United States. There is only one other possible way of transmission, and that is in sufficiently large lumps of earth, either as larva, pupa, or beetle. Now, if American dealers be required to carefully avoid the use of the haulm, and to ship none but clean potatoes, as free from


Fig. 4.—Bogus Colorado Potato-Beetle.

*a, a*, eggs; *b, b*, larva; *c*, beetle; *d*, left-wing cover, enlarged, showing marks and punctures; *e*, leg enlarged. Colors: of egg, pale-yellow; of larva, cream-yellow; of beetle, black, yellow, and brown.

earth as possible, the insect's transmission among the tubers will be rendered impossible; and when such precautions are so easily taken, there can be no advantage in the absolute prohibition of the traffic in American potatoes. As well prohibit traffic in a dozen other commodities, in many of which the insect is as likely to be imported as in potatoes. The course recently adopted by the German Government,

in accordance with the suggestion made in my last report, is more rational, and will prove a better safeguard: It is to furnish vessels, plying between the two countries, with cards giving illustrated descriptions of the insect in all stages, with the request that passengers and crew destroy any stray specimens that may be found. Let England and Ireland, together with the other European governments, coöperate with Germany in this plan, and have such a card posted in the warehouses of seaport towns, and the meeting-rooms of agricultural societies, and a possible evil will be much more likely avoided." Some English journals are discussing the question as to whether, with the more moist and cool climate of this country, the ten-line potato-beetle would thrive here even if imported. "There cannot be much doubt that it will rather enjoy the more temperate clime; for while it thrives best during comparatively dry seasons, both excessive heat and drought, as well as excessive wet, are prejudicial to it. It is argued by others that on the Continent of Europe our *doryphora* would not thrive if introduced; and, in a recent letter received from M. Oswald de Kerchove, of Gand, Belgium, author of an interesting pamphlet on the insect, that gentleman says, 'I do not think that the *doryphora*, awakened by our early warm weather, could resist the effects of the late cold which we are apt to have in these European countries.' The idea that the climate of North America is less extreme than that of Europe is rather novel to us of the cisatlantic; and, from a sufficiently long residence in England, France, and Germany, I am decid-

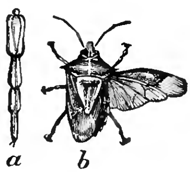



Fig. 5.—Spined Soldier-Bug.
*a*, beak enlarged; *b*, perfect insect, with the wings expanded on one side. Color, ochreous.

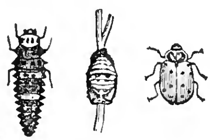


Fig. 6.—Convergent Lady-Bird.
Larva, pupa, and beetle. Colors, orange, white, and black.

edly of opinion that they delude themselves who suppose that *doryphora* could not thrive in the greater part of Europe; and that to abandon all precautionary measures against its introduction on such grounds would be foolish. An insect which has spread from the high table-lands of the Rocky Mountains across the Mississippi Valley to the Atlantic, and that flourishes alike in the States of Minnesota, Wisconsin, and Connecticut, and in Maryland, Virginia, and Texas—in fact, wherever the potato succeeds—will not be likely to be discomfited in the potato-growing districts of Europe. Some few, again, have ridiculed the idea of the insect's passage to Europe in any state, arguing that it is an impossibility for any coleopterous insect to be thus transferred from one country to another. Considering that half

the weeds of America, and a large proportion of her worst insect pests, including two beetles, viz., the asparagus-beetle (*Crioceris asparagi*) and the elm-leaf beetle (*Galeruca calmariensis*), in the very same family as our *doryphora*, have been imported from Europe, there would seem poor foundation for such an argument. Moreover, a number of other insects—among them some beetles—of less importance, may be included in the number of importations; and the rape-butterfly (*Pieris rapæ*), whose progress westward has been simultaneous with that of the *doryphora* eastward, and whose importation dates back but a few years, bears witness to the fact that insects more delicate, and with fewer chances of safe transport than *doryphora*, may succeed in getting alive from one country to the other, and in gaining a foothold in a new home. The ravages of the insect, bad as they are, very naturally get exaggerated at such a distance from its native home, and the following from an English gardening periodical gives altogether a too gloomy picture: 'When once a field of potatoes has been attacked, all hopes of a harvest must be given up; in a few days it is changed into an arid waste, a mere mass of dried stalks.' It should not be forgotten that the American cultivator, by means of intelligence and a little Paris-green, is pretty much master of the *doryphora*." It is to be hoped that this exposition of the facts and probabilities of the case will put people on their guard, and cause intelligent action to be taken to prevent the importation of so dangerous a pest as this potato-beetle.—*The Garden.*

## PASTEUR ON FERMENTATION.[1]

TRANSLATED BY L. A. STIMSON, M. D.

DURING the months of March and April a spirited discussion took place in the Académie de Médecine, at Paris, on fermentation and kindred subjects, in the course of which M. Pasteur was called upon again to sustain and develop his theory of this process, which is now so generally accepted. His share in the discussion was marked by the brilliancy of exposition and accuracy of experiment which have made him perhaps the most formidable debater among our modern *savants*. We have not here the space to speak of the certainty with which he seizes upon the central point of the discussion, and the tenacity with which he clings to it, the rapidity with which he exposes the weak points of an adversary's argument, and the absolute confidence shared even by his bitterest opponents in the accuracy of his experiments and statements. What now follows is the

[1] Bulletin de l'Académie de Médecine, 2d and 9th of March, 1875.

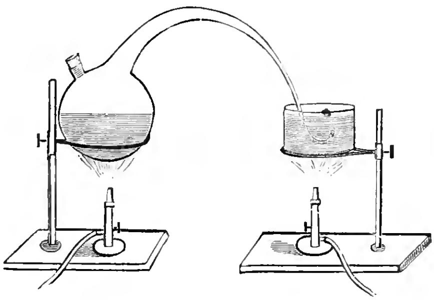
substance of two papers read by M. Pasteur, which have been condensed in the translation only so much as was rendered necessary by the limited space which could be given them.

M. Pasteur: At the last meeting of the Academy, M. Bouillaud asked me the following question: "*What are the ferments of the ferments?*"

Before entering into the details required by the answer to this question, it is indispensable that I recall the results communicated by me to the Académie des Sciences a week ago, for it is a question of life under circumstances hitherto ignored. The gist of the communication to which I refer lies in this proposition—the expression of rigorously-conducted experiments—that there are circumstances under which life may appear and be kept up without the presence of air, and consequently with the entire absence of free oxygen.

Here is a 3-litre flask containing 75 grammes of pure lactate of lime, about half a gramme of the phosphate of ammonia, about 0.4 gramme of the phosphate of potash, 0.3 of the chloride of magnesium, 0.2 of the sulphate of ammonia, and a very small quantity of the sulphate of soda. We may substitute advantageously for all, except the lactate, a salt of ammonia and the ashes of an inferior organism, brewer's yeast, for example.

We boil the liquid contained in the flask, while the extremity of this curved tube, which is so placed that it will collect all the gases that may be liberated, is plunged below the surface of another portion of the same liquid contained in another vessel, which is also boiled at



the same time. The object of this operation is to deprive the contents of the flask entirely of air. We then let it cool and carry the curved end of the tube into a vessel filled with mercury.

This liquid thus arranged would remain inert forever, either protected from contact with the air, as it now is, or in contact with it, provided the air were entirely free from organic dust. Nevertheless it is suitable for the nourishment of certain beings, notwithstanding its purely mineral composition. But life is absent and would

remain absent forever, because that which constitutes essentially the life of those beings, for the nourishment of which this liquid is appropriate, has not been added. Let us then introduce life there, let us sow vibrios in it. We place in the little funnel which surmounts the straight tube of our flask, the one closed by a glass faucet, a small quantity of one of those organic liquids in which vibrios are found after exposure to the air; or, better yet, and that is what has been done here, let us place in the funnel some liquid, the same exactly as that contained in the flask, but which has been exposed to the air and in which vibrios have appeared. Let us now turn the faucet and introduce a few drops with their vibrios into the flask.

Singular phenomena appear soon after this sowing of life in our mineral solution. The liquid, which was as limpid as distilled water, becomes little by little opalescent during the following days, and at the same time gases are set free and rise in the form of small bubbles to the top of the flask. This gas is a mixture of hydrogen and carbonic acid, and at the same time the lactic acid is transformed into butyric acid, which unites with a part of the lime of the lactate, the rest of which combines with the carbonic acid. It is a real putrefaction of the lactic acid which has taken place, but a putrefaction without putridity, for the lactic acid contains neither sulphur nor phosphorus, those elements of offensive gaseous combinations which are deleterious for man but inoffensive for vibrios. No, I am wrong: putridity shows itself, but in so slight a degree that it is almost inappreciable. Phosphorus and sulphur are present in the phosphates and sulphates; these are decomposed, hence a slight odor and even quite frequently a gray color given to the precipitate, probably by a little sulphuret of iron, for iron is almost always present, even in the purest materials.

Whence come all these mysterious transformations? Microscopical examination of a drop of this liquid which has lost its primitive limpidity will tell us. Wonderful spectacle! Beings in the form of small rods go and come, stop and recommence their movements. They are single or united in pairs, twos, threes, and even more. Here are a pair which separate from one another by a sort of effort, more or less prolonged on the part of the two individuals composing it. And now each half has its own movements; this is generation by scission. Now I know why the liquid is milky. What our eyes in their weakness call milkiness the microscope shows us is a consequence of the life of these little beings and of their incessant movements. And the experiment, patiently followed out, will tell us that the life lasts as long as does the principal food of our little beings, that is, the lactic acid of the lactate of lime, provided always that all the other general conditions of existence be satisfied; for it is not enough to have food at our disposal, we must be able to assimilate it, and it is necessary that the functional trouble which you call *pathology* should

not come to interfere with life and health. In a moment, if you choose, I will make them ill, all these little beings.

We have not finished with the peculiarities of our experiment, which will appear the more remarkable and instructive as you study it more closely. Let us weigh the vibrios that have been formed when the process ceases, when all internal movement has disappeared, and when they have fallen inert to the bottom of the flask, because they have exhausted their principal food, the lactic acid, transforming it into butyric acid, which is absolutely unfit for their existence, you will know why in a moment when I describe fermentible materials. Let us compare this weight of the vibrios with that of the 75 grammes of the transformed lactate of lime. The difference is considerable. I cannot now give you the exact figures, but the proportion is at the most as 1 to 200. What does that mean? an agent which causes the decomposition of a weight of matter 200 times as great as itself! But that is the characteristic of the phenomena to which chemists have given the name *phenomena of fermentation*. Yes, we have had to do with a real fermentation, in which the lactic acid is the fermenting substance and the vibrios the ferment.

Who would dare now to maintain that fermentations are phenomena of contact, phenomena of movement communicated by an albuminoid substance which is undergoing change, or of phenomena produced by semi-organized substances which are being transformed into this or into that? All these scaffoldings built by the imagination crumble before our experiment, so simple and so demonstrative.

Still, the most essential and, so to speak, dominant circumstance in our experiment has not yet been introduced, and it is time for me to submit it to your attention.

We prepared at the beginning a nutritive liquid, deprived entirely of air and protected from contact with it; we then sowed vibrios in it, and, during the weeks that have elapsed, our liquid has never been uncovered. Nevertheless, the vibrios have multiplied infinitely. Here, then, is life—that is to say, nutrition and generation—without the slightest aid from air or free oxygen. And in this experiment two things have marched side by side, life without air and fermentation. Ah, if that was a general phenomenon; if life as we know it, with absorption of free oxygen, was not accompanied by fermentation properly so called; if the weight of assimilated food corresponded to that of food ingested and used under the influence of respiration; and if, on the other hand, life without air was always associated with fermentation; if, in the latter case, life resulted in the transformation of an enormous weight of food as compared with the weight of the nutritive assimilation—should we not have raised the veil of these mysterious phenomena of fermentation?

From the moment it should be established that there is correlation between the fact of life without air and the fact of fermentation,

should we not have discovered the cause of this important phenomenon? The real causes of phenomena escape us. In sound philosophy the word *cause* should be reserved for the divine impulse which formed the universe. We can detect only correlations. One phenomenon succeeds another, and cannot exist without its manifestation; by abuse of language we then say there is relation of cause and effect.

Well, it is so. This phenomenon is general. Yes, when there is life without air, there is fermentation, and when there is fermentation there is life without air.

We all know that fruits detached from the tree and exposed to the air live, if we may so express it, like animals and certain inferior plants, for they absorb the free oxygen which surrounds them, and exhale a volume of carbonic-acid gas about equal to that of the oxygen which is introduced into their cells to produce in them certain manifestations of life, for the fruit continues to ripen. That being admitted, let us place a fruit, not in the air, but in carbonic-acid gas. Of two things, one, life, or, if you prefer, a certain chemical process, will go on in the cells of the fruit, or all chemical change will be absolutely suspended. If the latter hypothesis should be realized the fruit would remain inert, intact, and we should there have an admirable means for the preservation of fruit. But that is not the case: experiment proves that it is the first hypothesis which is realized; the simplest observation shows that fruit plunged into an atmosphere of carbonic-acid gas is modified more or less profoundly. Plums, for example, become hard and woody, and the grape takes exactly the flavor of the vintage. Where, then, have the cells of the fruit, in order to accomplish this chemical work, which, like all other work, requires the consumption of heat—where, I repeat, have they found the heat needed for these modifications, for this sort of life continued under abnormal conditions? Certainly it does not come from combustion, due to free oxygen, as when the fruit is suspended in ordinary air, for in this atmosphere of carbonic-acid gas there is no free oxygen. This heat, indispensable to the phenomena which observation detects, is furnished by the decomposition of sugar. The position is the same as in the case of the decomposition of sugar in the presence of yeast-cells living without air. This decomposition of the sugar is manifested in the fruit by the production of alcohol and of carbonic acid. Here the ferment is the cell of the parenchyma of the fruit. There is in this cell a life kept up, or a chemical process accomplished, without air; according to our theory, fermentation should be present there, and experiment shows that it is. The theory, then, receives from this fact an extension and a generalization which increase and strengthen it.

That is why in my last communication to the Académie des Sciences I expressed myself thus: "Every being, every organ, every cell which has the faculty of accomplishing a chemical process with-

out using free oxygen gas, produces at once phenomena of fermentation."

I have not yet made the experiments, but every thing leads me to believe that animal cells should act like vegetable ones. Death cannot suppress instantly the reaction of the solids and liquids in the organism. I am convinced, but it is as yet only a preconceived idea, that on asphyxiating an animal suddenly there should appear here and there, and perhaps in all parts of his body, acts of fermentation whose slight duration or intensity have prevented their detection hitherto. Perhaps I may soon bring before this Academy the result of an experiment which would consist in tying firmly the limb of an animal so as to stop the circulation in it, and then plunging it into an atmosphere of carbonic-acid gas. What will take place in this limb thus stricken with death? A sort of physical and chemical life, if I may so speak, will continue and will probably manifest itself by phenomena of gangrene which I have long considered as having but distant connections with putrefaction, and which, in my opinion, might be classed with the phenomena offered by a fruit detached from the tree which bore it.

I shall now answer M. Bouillaud's question, "WHAT ARE THE FERMENTS OF THE FERMENTS?" In other words, "How can the ferments which are living beings, and which contain materials of the same order as those of all living beings, decompose after the decompositions which they have themselves provoked? How can they be destroyed and disappear, or at least be reduced to the germs alone, which are eternal, so much at least as life may be eternal on the surface of the earth? How can the materials which compose them become gaseous and return to the atmosphere in the more or less mineral forms of vapor, carbonic-acid gas, hydrogen, nitrogen, ammonia, etc.?"

Although in the transformations to which I allude, and which will now occupy us, Nature obeys a very small number of perfectly-determined general laws, the phenomena present an infinite variety in the details, and if I wished to include all the forms of the return to the air or soil of organic matter after death, it would require time and space which are not at my disposal; but as amid the thousand variations of the phenomena a very small number of laws preside over their manifestation, as these laws are found in all the individual cases, I cannot answer the question of our illustrious associate better than by taking a definite example, following it through all its phases, and then adding, "*ab uno disce omnes.*"

I shall take the return to the atmosphere, and to the soil, of one of the most precious fruits of the earth, the grape, and, far from restricting the difficulty, I shall take it in its greatest complexity. It is unnecessary to say that instead of the grape I might have taken any other woody or leafy organ, either of the vine or of any other plant,

and you will also understand that this example embraces the destruction of all the species by which life is manifested upon the face of the earth.

If I should describe the destruction of a single grape, abandoned to itself, I should show you only one of the laws of the phenomena; but there are two principal ones, and in order to pass them both in review I shall suppose that all the fruits of a vineyard have been gathered and placed in a gigantic heap, in an immense reservoir, as large as a mountain, if you choose. Under the influence of the weight the grapes are separated from the stems, broken more or less, and allow their contents to escape in the form of a sugary liquid. By a fortunate coincidence (which M. Colin might at his ease and by the aid of sentiment look upon as an express desire of Providence to furnish man what is called wine), it happens that at the period of the maturity of the grape its surface and that of the stems are covered here and there in the form of a fine dust by an extraordinary number of the germs of a small cellular plant which has the faculty, its germination once commenced, under the influence of a very small quantity of air, to multiply indefinitely in the entire absence of free oxygen gas—this was proved at our last meeting—and to provoke, correlatively with its life, the decomposition of sugar into carbonic-acid gas which is set free, and an alcohol which remains in solution in the liquid.

In the must of the grape the principal substance, after the water, is the sugar; it constitutes 20.25 parts in 100, sometimes even more; now, the decomposition accomplished by the ferment of which we have just spoken eliminates in the form of carbonic-acid gas more than half of this sugar, and thus a considerable portion of the organic matter of the grape returns to the atmosphere.

This singular phenomenon, which has struck the imagination of men ever since the beginning of the world, is accompanied by an intense heat and a bubbling of the whole mass, but as the sugar disappears the movement slowly ceases. As soon as quiet is restored, our immense cask is found to be filled with an alcoholic liquid which is the habitual drink of men living in southern countries. Scarcely has the carbonic-acid gas ceased to escape, when an attentive eye sees a pellicle form upon the surface, a pellicle which is extremely thin and insignificant in appearance, but in which reside a new life and new phenomena well worth our attention: this pellicle is formed of a mycodermic plant (of two, in fact, but for the sake of brevity I shall consider only one) which, strictly speaking, we might class with that one which has just flourished in our cask and decomposed the sugar, but which has now fallen inert to the bottom. Still, if our two little plants resemble one another in their anatomical structure, they are very different physiologically. The cells of the ferment which destroyed the sugar lived and multiplied without air; the new cells, on the other hand, spread over the surface of the liquid in an unbroken pellicle,

cannot live without the aid of the oxygen of the air. Furthermore, they fix this oxygen upon the alcohol contained in the wine according to the following equation: 46 parts, by weight, of alcohol unite with 32 parts of oxygen to form 60 parts of acetic acid and 18 parts of water. The combustion which results from the taking up of these 32 parts of oxygen is such that the whole surface of the liquid to a certain depth shows a temperature several degrees higher than that of the deeper portions; clouds of vapor rise above the cask, clouds formed mainly of steam, mingled with a few odorous products and some vapor of acetic acid. Little by little all these external phenomena diminish and finally cease entirely, and the mycodermic pellicle falls inert to join the preceding ferment at the bottom of the reservoir. And now instead of a reservoir of wine we have a reservoir of vinegar, in which our learned colleague may again see, at his leisure, and still sentimentally, a result of divine foresight, in the form of a final cause.

But let us continue. Our task—that is, the determination of the return of the organic matter to the atmosphere and to the soil—has been very little furthered by the second phase of the phenomena which we have just described; the alcohol, 100 parts of which contain more than 52 parts of carbon, more than 13 parts of hydrogen, and nearly 35 parts of oxygen, all coming from the original sugar, has indeed disappeared and given place to the acetic acid, but the matter has not become gaseous, it has not returned to the atmosphere as it partly did at the beginning. All the carbon of the alcohol has remained in the newly-formed acetic acid.

Notice what now takes place in our immense reservoir of vinegar, at the bottom of which lie heaped together the stems, the pellicle, the pits, the cells, the parenchyma of the fruit, and our two ferments, the wine-yeast and the vinegar-yeast. The quiet of which I spoke, and which was established a moment ago, has not lasted long: the ferment of the vinegar (and the fact is very curious) which has just fallen to the bottom of the cask, exhausted by the immense chemical work which it has produced, rendered inert by the sharp combustion of which it has been the seat, reappears, little by little, on the surface of our acid liquid, always in the form of a very thin pellicle; and, little by little, again the upper strata of the vinegar heat, and again clouds rise above the liquid. These clouds are no longer composed solely of the vapor of water; the latter is still very abundant in them, but it is mingled with torrents of carbonic-acid gas, and this remarkable phenomenon continues as long as any acetic acid remains in the liquid; in other words, after the vinegar ferment, an *aërobic* ferment—one needing air—has burned the alcohol and turned it into water and acetic acid, it burns the latter and turns it into water and carbonic acid. It also burns the original acids of the grape.

This time, that is, in the third phase of the phenomena, the return to the atmosphere has gone on rapidly: all the carbon, all the hydro-

gen, all the oxygen of the original sugar, are now in suspension in the air in the gaseous state, ready to be borne away by the winds and again to enter into the cycle of life under the influence of the beneficent heat of the sun. It is here that I would place the providential idea, not sentimentally only, this time, but by a real and serious scientific deduction, and because it seems to me that we have seized one of the great laws of Nature.

Let us return a little upon our steps and see where we are. What is the condition of our liquid mass? It is now only water holding in solution a very small quantity of mineral or organic substances. Evaporation would promptly reduce the whole mass to the deposit of which I spoke a moment ago, and which is lying at the bottom of the vessel, the wine-yeast, the vinegar-yeast in two portions, that which formed the vinegar and that which destroyed it, together with the stems and skins of the grapes.

What is going to take place in this liquid mass, no longer acid, but neutral now, in which there is held in solution only a little mineral and nitrogenized matter, which, it is true, is always ready to be renewed, at least for a long time, by the help of the materials at the bottom, which, thus far, have undergone nothing but simple maceration?

Pressed for time, I was only able at our last meeting to begin my answer to M. Bouillaud, and to do that even in terms so far removed from the subject that you must have found it difficult to understand the connection of the phenomena then described with the real object of the question. This connection, prepared by what has preceded, will now seem very clear.

Have we not reached a point in the succession of the grand natural phenomena which I am passing in review, at which we have to deal with a liquid of absolutely the same kind as that which I showed you at our last meeting, and one which is even more suitable for the phenomena of putrefaction of which I then spoke? If the liquid of our great reservoir is now formed of distilled water, phosphates, chlorides, and sulphates, there is at the bottom, to replace the lactate of lime of last Tuesday's experiment, a collection of carbonized or nitrogenized substances much better fitted than lactic acid to supply the carbonic food suitable for the development of the vibrios.

And, in fact, scarcely has the last mycodermic pellicle fallen to the bottom, scarcely have a new death and a new quiet fallen upon our liquid, scarcely has it lost all acidity, when, little by little, it becomes cloudy throughout; germs floating in the air have brought to it a new life, not one like those which you have seen precede it, but another, one rendered possible by the neutral character of the new liquid. The whole surface becomes covered by a layer of fatty, mucilaginous aspect. In the deeper portions, throughout the whole mass, as I said, we see a milky cloudiness; at the same time an infectious and very deleterious odor announces, even at a distance, the putrefaction and

the danger. It is thus that a part of the sulphur, phosphorus, and nitrogen of the sulphates, phosphates, and nitrogenized substances, return to the atmosphere in the form of gaseous products, but they will not long remain deleterious, for the oxygen of the air decomposes them incessantly, and transforms them into gaseous products useful to vegetation.

I spoke of a fatty, humid pellicle, formed on the surface, and of a milky cloudiness, occupying the whole mass: examine the pellicle under the microscope; the smallest fragment of it shows us millions of bacteria; below it, even in the deepest layers, a drop of the liquid presents the vibrios of putrefaction without a trace of bacteria. The bacteria are only on the surface, because they are *aërobic*, that is, they need air to live; the vibrios are below, because they do not need air to live, and, indeed, the layer of bacteria protects them against the approach of the oxygen gas which would be fatal to them if too much of it were held in solution by the liquid.

While the vibrios transform a large part of the solid materials macerating in our liquid into the gaseous products of putrefaction, the bacteria of the surface fix a considerable amount of the oxygen of the air upon the carbonic substances held in solution, and now again large quantities of carbonic-acid gas are set free. But, little by little, the medium which at first was so suitable for the nourishment of bacteria and vibrios becomes less so, a change which is announced, especially as to the bacteria, by a steadily-decreasing appropriation of the oxygen of the air; then appear, here and there, on the surface of the fatty pellicle, greenish, *glaucous* spots which increase as life becomes less active in the bacteria. These spots are spots of mould, new aërobic beings like the bacteria, and which find in the latter an appropriate food; little by little, the whole surface of the liquid will thus become covered by differently-colored moulds. Like the bacteria and the mycodermic pellicles, these moulds also cause much oxygen to combine with the subjacent substances which serve as their food, and again carbonic-acid gas is set free.

You see, then, that the substances dissolved in the liquid of our reservoir and deposited upon its bottom are constantly becoming gaseous and mineral. But during the continuance of all these phenomena, which last for months or for years according to the quantity of original material and the state of the atmosphere, an incessant evaporation, much increased by the heat of the successive combustions of which the surface of the liquid has been the theatre, has removed most of the water contained in the reservoir, and the latter dries, leaving on the bottom an insignificant quantity of each of the substances originally deposited there; but the combustions go on: here by the moulds, there by bacteria, monads, kolpods. When a mould has exhausted, if we may so call it, the appropriation for its life furnished by that portion of the surface or of the material upon which it has lived, it is replaced by an-

other to which, in turn, it serves as food. And observation shows that, so long as there remains any organic matter which can furnish carbon, the life of the moulds or of the infusoria is prolonged, but always with the result of setting free, in the form of carbonic acid-gas, a part of the carbon, while the life draws its other materials from the mineral salts and from the nitrogen of the ammonia compounds. The saline substances indeed are very abundant, for at no time have they been able to take on the gaseous form. And, finally, what remains? 1. Ashes, as if fire had been applied to the matter, for these slow successive combustions have produced the effect of fire; 2. The last germs of the last beings which lived upon the remains of their fellows. The mineral substances are ready to return to the soil, the organic matter has passed into the air, and when all shall have become dry the spores of the moulds and the cysts of the infusoria will be borne away upon the wings of the wind to recommence, elsewhere, their work of life and of destruction of life.

The ferments, and especially the aërobic ferments or the beings which are like them, are then the ferments of the ferments.

After the anaërobic ferments have commenced the disorganization of the material, the aërobic beings intervene and burn the organic matter as completely as it would be burned by fire—more slowly, it is true, but of what importance is time in the work of destruction by the life of germs?—for it is in them alone that resides the perpetuity of the life of microscopic beings.

# CROLL ON CLIMATE AND TIME.[1]

By E. LEWIS, Jr.

THE distribution of temperatures upon the globe is a subject of profound popular and scientific interest. More than any other, it affects the distribution of living forms, not only in zones of climate, but in geological time. The contour of the earth's surface, and the relations of land and water upon it, may produce important local changes, or establish local faunas and floras, but these are scarcely more than modifications of grander and more general results. Arctic plants may, indeed, flourish under the equator, but only on mountains where an arctic climate prevails. Heat determines the limits equally of the vine, the palm of the tropics, the cereals of the temperate zone, and the food of the reindeer. Whether or not tree-ferns grow in Pennsylvania, and forests of pine in the Arctic Circle, depends on cli-

[1] Climate and Time in their Geological Relations: a Theory of Secular Changes of the Earth's Climate. By James Croll, of Her Majesty's Geological Survey of Scotland. New York: D. Appleton & Co. 1875

mate. Nor is this a phenomenon of the present age only. Geology proves from its records that, while a torrid zone may have existed since climates began, yet polar and temperate regions have witnessed changes both of climate and of life in wonderful succession, and in periods of immense duration. The causes which have contributed to these results have been sought and studied by some of the most eminent scientists of our time. Humboldt, Sir John Herschel, Sir William Thomson, Lieutenant Maury, Sir Charles Lyell, and more recently Dr. Carpenter and others, have investigated the subject in many of its aspects, and their conclusions are before the world; but no one, we believe, has presented it from so many points of view, or attacked its complex problems with greater vigor, than Mr. James Croll, whose volume is now before us. His conclusion is, that not only great secular changes of climate, but the distribution of temperatures upon the earth's surface at the present time, are due to causes which alter the volume, intensity, and direction, of the trade-winds and other prevailing winds of the globe. For the question at issue is not the amount of heat received upon the earth's surface, but the means by which it is distributed. It is not claimed that the great heat of the equatorial regions is carried directly to the polar regions by winds. That such a result is impossible is shown by the fact that the heated air rises at the equator, and moves toward the poles at an elevation where the temperature is at freezing, and its heat is lost or radiated into space.

But the prevailing winds, and mainly the trades, give rise to great surface-movements of the ocean, chief of which is the Gulf Stream. Here, however, the author enters on disputed ground. We have not space to follow him in his criticisms on Lieutenant Maury and Dr. Carpenter, each of whom attributes oceanic circulation to difference of specific gravity of the water rather than to winds.

It is evident, however, that the value of this question depends upon a previous one, What influence have ocean-currents on climate, and what is their capacity for the transference of heat? For clearness and brevity we will confine our inquiry to the North Atlantic and its great current, the Gulf Stream. By one of the lowest estimates made of the volume and velocity of this stream, there is conveyed by it not less than 2,787,840,000,000 cubic feet of water every hour. This is about 1,200 times as much as the average hourly discharge of the Mississippi. "No droughts affect it;" the flow is incessant, and the volume continues unchanged, save by causes which we will presently mention.

The mean temperature of this water as it emerges from the Gulf is about 65° Fahr. As the stream spreads over the North Atlantic its heat is imparted to the atmosphere, and diffused by winds. It is certain that the entire volume of Gulf-Stream water loses in this way 25° of its heat; and this represents its warming capacity. To this we refer the mild climate of England, of Norway, and Iceland. The heat thus

conveyed and distributed by each cubic foot of water is 1,158,000 foot-pounds,[1] and by the whole volume of Gulf-Stream water there is transferred every day from the equatorial regions 77,479,650,000,000,000,000 foot-pounds of heat. But these figures convey no definite impression of the vastness of the results. It is equal to one-fourth of all the heat received from the sun by the whole Atlantic Ocean from the Tropic of Cancer to the Arctic Circle, raising the temperature of its waters one-fifth—it is equal to about one-half the solar heat which falls upon the entire arctic regions. Under the equator there comes from the sun on each square foot of surface about 83 foot-pounds of heat every second, when the sun is in the zenith. Twenty-two per cent. of this is absorbed by the atmosphere; the remainder falls as heating-power upon the ocean. Now, the quantity conveyed is equal to all that thus falls upon 1,560,935 square miles of surface. If this source of heat be destroyed or turned away, the area of arctic winter would rapidly extend southward, covering England, both Old and New, with ice which the heat of summer would not remove.

Nor would any conceivable movements of the atmosphere supply the deficiency of heat. For not only does heated air at the equator rise, and radiate its heat in the cold regions of the upper atmosphere, but the capacity of air for heat is much less than water. So great is the difference in this respect that the Gulf Stream conveys as much heat as a current of air would if 3,234 times as large, of the same temperature, and moving with the same velocity. The heated air, however, which rises at the equator is charged with vapor, and in the opinion of Sir John Herschel this vapor, conveyed by the upper or anti-trades, is condensed in the temperate and arctic regions, greatly modifying their temperature. To the extent that the vapors are thus conveyed, the conclusion of Sir John is correct; for, as Prof. Tyndall has shown, in the conversion of one pound of aqueous vapor into water there is given out as much heat as is sufficient to melt five pounds of cast-iron. But Mr. Croll proves that the greater part of the vapor raised in the equatorial regions falls there as rain; that the upper winds are dry, and gather moisture only when they again reach the earth and become surface-winds in the temperate and arctic zones.

If all currents of the ocean and atmosphere should cease, no heat could be transferred from the equatorial to the arctic regions, and temperatures would depend on the solar heat falling in the respective latitudes. The equatorial and arctic regions would become uninhabitable, the mean temperatures rising to 135° Fahr. in the one, and sinking to 83° below zero in the other. The present difference of 80° would be increased to 218°, and only a narrow zone of temperate climate would prevail.

[1] A foot pound is the amount of heat-force expended in raising one pound one foot; 772 foot-pounds is the equivalent of the heat that will raise one pound of water one degree of temperature.

Dr. Franklin suggested that the Gulf Stream has its origin in the trade-winds. It was a crude but sagacious remark. Lieutenant Maury, however, thought the cause wholly inadequate, and that the phenomenon is better explained by difference in the density and specific gravity of ocean-waters, arising mainly from differences of temperature. Dr. Carpenter, too, insists on difference in specific gravity as a cause of ocean circulation, but claims that the circulation is a diffused or general one of the ocean-waters between poles and equator, and attaches comparatively little importance to the Gulf Stream. Mr. Croll, however, revives the views of Dr. Franklin with surprising ability, and finds in the great wind-currents, and chiefly in the trade-winds, a cause adequate to the result. The wind and ocean currents coincide all over the globe. The waters move with the general set of the trade-winds—the direction of the one is a reliable exponent of the set of the other.

Now, it is obvious that any influence which changes the direction of the winds will also affect that of the currents, and in that way the climates of the globe.

At present the equatorial waters heated by the sun to a temperature of 83° move westward between the tropics at the rate of thirty miles in twenty-four hours. This is called the equatorial current. It impinges upon the coast of South America, a small portion going southward, the principal portion northward, and is discharged as the Gulf Stream. It is deflected every year by changes in the trade-winds; it is thrown northward when the southeast trade is at its maximum. We will confine our attention now to the northeast trades. Should these be increased in velocity and volume, they would also assume a somewhat more northerly direction at the equator, carrying the equatorial current southward beyond the median line, and increasing the volume of the southern at the expense of the northern flow. From this cause the temperature of the Northern Hemisphere would be greatly lowered, while the mildness of summer would prevail in the Southern Hemisphere.

Causes, therefore, which alter the force and direction of the trades are adequate to change the climates of the globe, and in the opinion of Mr. Croll these causes are found in variations in the earth's path around the sun, combined with the precession of the equinoxes. These affect not, indeed, the total volume of heat received by the earth in a year, but the distribution of it by the means already referred to. If it happen that during a vast period of time the winters of our Northern Hemisphere should occur when the earth is farthest from the sun, and its orbit at its greatest eccentricity, the result would be winters long and cold, with summers short but hot. The earth would in that case be 8,641,870 miles farther from the sun in winter than at present, and during that season would receive one-fifth less direct heat from it. At present the winters are eight days shorter than the summers, but

in the conditions referred to the winters would exceed the summers by thirty-six days.

It is not claimed by Mr. Croll that a cold or glacial epoch is directly caused by the increased distance of the earth from the sun, but from physical agents thus brought into operation. Some of these we will proceed to mention.

As the winters increase in length, and the cold in intensity, the volume of snow-fall will become greater, and its area extended. The limit at which the summer sun melts it will move slowly southward. Behind it will be a gradual accumulation of snow forming into ice. Mountain-slopes will be covered with it, until it flows down into valleys and onward, a vast sheet of glacial ice, equally on lowlands and mountains.

Out of this condition will arise several results which powerfully react, increasing and intensifying the cold of the growing winter. A volume of snow and ice covering the ground chills the air by direct radiation, and by contact lowers its general temperature, thus delaying or arresting the process of melting by the summer's sun. It is a familiar fact that in snow-covered regions the direct rays of the sun may be intensely hot, melting pitch from timber, or heating rocks, while the temperature of the air is that of the ice upon the ground. The regions of Hudson Bay are sterile, not because the heat from the summer sun is not intense, but because they are covered with ice all the year. But for this the climate might be as genial as that of England. Ice and snow maintain steadily a temperature of 32°, no matter how hot the sun's rays may be, and a rock or piece of earth will become greatly heated, while a block of ice consumes the heat that falls upon it. The solar heat is, therefore, expended in breaking down the molecular structure of the ice, and must continue to do so until it disappears. By as much heat as is used over a region in this way is the heating effect of the sun's rays diminished, and a low atmospheric temperature is the result.

But the sun's rays falling on snow are to a considerable extent reflected back into space from its innumerable surfaces, greatly decreasing their heating effect.

The snow-sheet exerts another important influence on temperature by condensing the vapor of the air into fogs as the summers come on. In this way the solar rays are arrested, and their heating power dissipated. This occurs continually during the summers of arctic and antarctic regions. Dr. Scoresby observes in regard to the arctic regions that "the sun, when near the northern tropic, gives scarcely any sensible quantity of light from noon till midnight; it is frequently invisible for several successive days, and snow is so common that it may be boldly stated that it falls nine days out of ten from April to July." These are the conditions of climate in which glaciers grow and throw abroad their chilling influence. We are now to consider

their relations to the atmosphere and ocean in respect to their movements. The trade-winds owe their existence to the difference of temperature between the equator and the poles. Whatever increases this difference increases the strength and volume of the winds, whether in the Northern or Southern Hemisphere. The coming on of a period of northern glacial cold would be concurrent with increasing violence of the northeast trade-wind. It would sweep at its maximum far beyond the equator, for the Southern Hemisphere would be heated and the line of greatest equatorial heat would be southward from its present position. A deflection of the great equatorial current of the ocean would occur corresponding with this, and its vast volume of heated waters would pour into the southern instead of into the northern ocean. The Gulf Stream would cease to flow, or flow only with greatly diminished volume. "In the severest droughts it never fails," said Prof. Maury, but it may fail from other causes, and leave half a hemisphere rigid from the austerity of cold. Depleted of the Gulf Stream, the surface-waters of the North Atlantic would be warmed only by the direct rays of the sun, and would rapidly approximate to the low temperatures which now prevail only a few fathoms beneath the surface. The mean temperature of Scotland for January is 28° higher than its normal, and 15° above its normal for the year. The loss of the Gulf Stream would change all this.

Theories which have made the Ice period depend wholly on cold are shown to be untenable by Prof. Tyndall, who calls attention to the fact that great heat is as necessary to the production and growth of glaciers as intense cold, the one being needed to produce vapor, the other to condense and freeze it. Any accumulation of snow and glacial ice is impossible without this combination of circumstances; but these constitute an integral part of Mr. Croll's theory, which assigns a mild climate to one hemisphere while the other is wrapped with ice.

Alternation of climates in geological time is as certain as diversity of climate at the present day. Evidence of it is found in the geological record, and eras of glaciation have succeeded each other, but each one has buried or erased many traces of preceding ones, and only the last one is before us, the monumental history of which reveals its startling and wonderful features.

It is held indeed by Mr. Croll that eras of cold and glaciers alternating with those of temperate climate are fully accounted for by the causes stated. His conclusions, however, are not accepted by many eminent geologists. Prof. Dana says that climatic changes effected by the Gulf Stream have been brought about, "not by diversions of the current from the ocean, and its restoration to it again, but by variations in the amount and height of arctic lands, in one case closing and the other opening the arctic regions to the tropical stream, and the same for the Pacific current." While this view may not call in question the warming influences of the stream, it assigns

other reasons than those given by Mr. Croll why its effects may be greatly varied. Nor can there be any doubt that changes in the general level of the land, altering coast-lines and the currents of both the atmosphere and the ocean, are important agents in modifying temperatures. We cannot follow into details Mr. Croll's exhaustive inquiries, but our readers will be interested in his answer to the well-known theory of Sir Charles Lyell. According to that eminent authority, a period of polar cold will result from a great increase of elevation and extent of land in polar regions, and a warm period in the polar zones will occur by a great accession of land in the equatorial regions. But Mr. Croll shows that such changes in the distribution of land would be followed by opposite results—that a great accession of land in the equatorial zone would destroy the system of ocean-circulation by which the heat of the equator is made to do service in warming the ocean and the air of colder zones.

In Mr. Croll's theory it is impossible that both hemispheres should be glaciated at the same time. Not only must periods of heat alternate with those of cold in one hemisphere, but a glacial epoch in one is accompanied by a temperate epoch in the other.

It is evident that changes of climate such as are shown to have occurred must have arisen from general, not from any local cause or accidental combination of causes, and if this be so there may yet appear a reliable means of determining not only the amount and extent of the changes, but the periods of their duration and recurrence. The question of time in geological history is an important and certainly a most interesting one, and the interest in it has increased since the announcement by Dr. Tiddeman and others that human relics have been found in deposits of the warm inter-glacial periods.

Two methods have been adopted by Mr. Croll which are supposed to throw light on this subject. One is to fix the period and duration of the epochs of greatest heat and cold by computing the period and duration of the astronomical coincidences already noticed, by which according to his theory those epochs were brought about. The other method is applied to estimating the time since the close of the last glacial epoch by changes known to have taken place in the earth's surface, and the general lowering of the land by denudation. To do this, he says, "we have only to ascertain the quantity of sediment annually carried down by the river systems."

By this means it is found that the lowering may have been nearly a foot in 6,000 years. But when we consider how greatly the general result may have been interfered with by the alternate elevation and depression of the land, a work now going on, we realize that Mr. Croll's conclusions do little more than profoundly impress the mind with the vastness of time required in some of the most obvious of Nature's operations.

By the first-named method computations have been made extending

back three millions and forward one million of years. But we believe that most geologists agree with the statement of Sir Charles Lyell that "an attempt to assign chronological value to any except the latest geological epochs must in the present state of science be hopeless."

It may be stated, however, that during the period covered by the computations, three epochs of greatest eccentricity of the earth's orbit occurred, and in each of these it is found that the eccentricity is not uniform, but rises and falls. Hence the coming on and departure of each period may have been continuous, but by no means regular. Sometimes the changes were at the comparatively short intervals of 10,000 or 12,000 years, and the close relation these changes may have had to the life of the time, possibly to extinction of species, is plausibly suggested by Mr. Croll.

The period of great eccentricity to which the last glacial epoch is referred began about 240,000 years ago, and extended over a period of about 160,000 years. The conclusion, therefore, is that it closed about 80,000 years ago. It is not easy to understand, however, what value to attach to the words "close of the glacial epoch." Shall we say that it closed when the ice ceased to exist as a glacier along the shores of New England, or when it extended no farther southward than the Canadian highlands? The gigantic fields of ice which now cover both arctic and antarctic lands prove that, within areas more limited indeed than in former time, the glacial epoch still exists in its stern and sublime reality.

Whether we consider the facts of geology or those of astronomical computation, it seems evident that the growth and decline of the ice-sheet, and of the causes which produced it, have been in no sense cataclysmic or accidental, but secular; only after ages have passed are we enabled to realize, from the altered aspects of Nature, that a great change is in progress. At present the eccentricity of the earth's orbit is diminishing. In a little less than 24,000 years it will be "as nearly circular as it can ever be;" and if Mr. Croll's tables are to be relied on, no cycles of extreme heat or cold will occur for the next 150,000 years. We are entering a period of comparatively equable climate, arising from a more uniform distribution of solar heat over the surface of the globe.

## THE ARTIFICIAL PREPARATION OF ORGANIC BODIES.

By IRA REMSEN,

PROFESSOR OF CHEMISTRY IN WILLIAMS COLLEGE.

THE "good, old" foundation upon which our fathers stood has been sadly shaken. Its complete overthrow has at times seemed inevitable. "Scientific men" have led the attacking army, and thus gradually brought themselves into disgrace with a portion of the

community. The fight has been carried on to a great extent blindly, and most attempts to establish order have only succeeded in increasing the confusion. Sorties from the camp of "the fathers" have been made, and weapons have been carried back; but, alas! the weapons were useless, or, if used, they injured the user. The conflict is still waging, and it will continue to wage. Occasionally faint promises of a better understanding are given, but some misguided enthusiast, on one side or the other, hastens to destroy the hopes of a happy issue. The frequent shocks received by "the fathers" have unduly excited them, and they look upon each advance of science as something dangerous. Often they do not stop to examine whether the movement of the hostile party is, or is not, antagonistic to their position, but blindly throw their whole force against it, and anxiously look for the results of the crash. It sometimes happens that they thus waste their force, and weaken themselves for future necessary encounters.

Dropping the figure, we may safely assert that those who are avowedly the opponents of science, though their objects may be the highest—though they may be actuated by only noble desires—have, unfortunately, from time to time brought ridicule upon themselves by upholding views which were not tenable, and which a careful examination and thorough knowledge of the subject would show to be unnecessary for the support of their theories. These somewhat trite remarks lead to a consideration of the subject embraced in the title of this paper.

There are certain chemical substances known to us which only occur in the organs of plants or animals. The number of these substances at present known is very great, and new ones are being rapidly added to the list. They consist often of but three elements—carbon, oxygen, and hydrogen; sometimes nitrogen is added to these, and, rarely, phosphorus or sulphur. Notwithstanding the fact that they are made up of few constituents, they are usually of complicated structure; indeed, the complication in some of them is so great that, with our present means of analysis, we are unable to express their composition by means of satisfactory formulæ. The substances referred to have been known by the name *organic bodies.*

Up to within a few years chemists were, to a certain extent, justified in drawing a line of division between two classes of bodies, both occurring in Nature: 1. Those which can be prepared in the laboratory; 2. Those which cannot be prepared in the laboratory. The second class included the so-called organic bodies. These were known to occur only in the organs of plants or animals. The two facts, taken together, were significant, and but little surprise can be expressed that a connection was traced between them. The simplest conclusion that could be drawn from the premises *was* drawn, and the scientific world, buoyed up by certain preconceived notions in regard

to life, tacitly accepted it. Chemical substances which are produced under the mysterious influence of life, in the dark, unfathomed cavities of living organisms, cannot be produced by the hand of the mortal chemist. This was the conclusion which grew to be a dogma, and was used as a kind of *ex post facto* argument in favor of certain views in regard to the so-called "vital force."

But its influence did not cease here. Having worked so beneficially as an important link in a chain of retrograde logical sequences, it was afterward made a starting-point for other lines of argument. It was employed in religious and purely philosophical discussions, and assisted in the establishment of subsequent illogical conclusions.

As these discussions were taking place, the chemist quietly continued his strange dealings with the elements. Discovery followed discovery, until the fact could no longer be doubted that the dogma must fall. Its fall was, however, not the matter of a moment. It received repeated blows before it gave up its existence. Its place has been taken by an hypothetical statement founded upon a large array of facts, viz.: every chemical body, no matter of how complicated a structure, or what its nature may be, will probably, in good time, be prepared artificially in the chemist's laboratory. And this statement becomes more and more probable every day. Already a large number of the compounds, the formation of which was formerly supposed to be dependent upon the action of the vital force, have been reproduced entirely independently of any suspicion of the action of this force; and thousands of other analogous compounds which have never been found in plant nor animal are now known to us. Let us look briefly at some of the steps that were taken in this advance of opinion.

In the year 1828 Wöhler made the first observation bearing directly upon this subject. A few years earlier he had discovered cyanic acid, and he was now engaged in the thorough investigation of this acid. He prepared its ammonium salt, and, on evaporating the aqueous solution of the salt, he noticed the formation of large, well-developed crystals that in every respect resembled *urea*. Urea was well known, but had, up to that time, only been found among the products formed in animal bodies. Its existence was, in accordance with the then prevalent views, supposed to be due to the inexplicable action of the vital force. A careful examination failed to disclose any points of difference between the two bodies, and Wöhler was forced to the conclusion that at least one organic substance could be prepared outside of the organism.

But this by no means brought about a change of views. The upholders of the old dogma immediately found relief which was apparently satisfactory. Cyanogen compounds, of course including cyanic acid, had only been prepared from substances which had had their origin in the organs of animals, and, although these original

substances had been subjected to purely chemical influences, and thus another animal substance produced, the vital force had nevertheless played its part as an essential agent in the formative process. This argument seemed plausible, and could hardly be objected to. Other and more decisive experiments were necessary.

In 1841 Fownes succeeded for the first time in preparing cyanogen directly from its elements. He passed nitrogen-gas over a mixture of charcoal and hydrate or carbonate of potassium at a red heat, and obtained a salt of cyanogen and potassium—cyanide of potassium. From this salt it was a comparatively simple matter to prepare all the other cyanogen compounds, and, finally, urea. Thus, then, there could be no doubt that a direct construction of some organic bodies from their elements was possible.

But urea, in comparison with most animal or vegetable products, is of simple structure. It contains but one atom of carbon in each molecule, whereas many others contain a very large number of carbon-atoms. The transformation of cyanate of ammonia into urea, which took place so readily, was a very simple one, if we consider merely the relation of the two bodies to each other. They have exactly the same composition. They contain the same percentages of carbon, hydrogen, nitrogen, and oxygen. A change of the arrangement of the atoms was necessary, but this was all—no addition of material, no building up, no binding together of a large number of atoms into one compound. There was still left something which could be ascribed to the influence of vital force, and this fact was seized upon and made to do service. It was now stated that, although it might be possible to prepare artificially some of the simpler organic bodies, the vital force was necessary to bring about the complicated form of union found in the greater number of the products of the life-process. This statement held its own for a number of years. In the mean time a series of brilliant experiments by Berthelot had established the fact that a large number of organic bodies could with ease be prepared artificially. In 1856 this chemist published the first results of his investigations. He had effected a direct union of carbonic oxide with hydrate of potassium, and thus obtained the potassium salt of formic acid. Later he showed that a direct union of carbon with hydrogen was possible; using carbon-poles, he passed a current of electricity through them in an atmosphere of hydrogen; he thus obtained acetylene, a hydrocarbon made up of two atoms of carbon and two of hydrogen. He also produced marsh-gas, ethylene, and a number of other hydrocarbons from inorganic materials which, in their turn, could be obtained from the elements. It was shown that marsh-gas could be converted into methyl alcohol; ethylene into ethyl alcohol; and from these alcohols it was an easy step to formic and acetic acid; to the aldehydes, amines, acetines, etc., etc. These results, although startling when viewed from the oldest stand-point,

could still be reconciled to these views as necessarily modified subsequently to Wöhler's discovery. The compounds thus formed artificially were still of comparatively simple structure; and, in the numerous transformations effected by Berthelot, in no case was the passage from a compound of a lower to one of a higher order. Marsh-gas, methyl alcohol, and formic acid, each contained but one atom of carbon; ethylene, ethyl alcohol, and acetic acid, each contained two atoms of carbon. Surely the vital force alone could build up more complicated bodies.

Not so. The series of advances in the new doctrine, thus so propitiously begun, did not stop. New methods of investigation were introduced. Questions of a different character were put to chemical substances, and answers were not wanting. The interest in chemical science increased, and the army of those who were to carry it forward also increased. The growth of the science became proverbially rapid, and, during the excitement attendant upon this development, the last of the old landmarks between inorganic and organic bodies was swept away; vital force, as far as it was directly concerned in the formation of organic bodies, lost prestige. Both classes of bodies were found to be subject to the same fixed laws. A chemical substance is a chemical substance, look at it as we will. Its constituents, in one case as in the other, are bound together by chemical affinity, simply and alone. Whatever the conditions may be which surround the formation of organic bodies in the animal or vegetable organism, the final combination of the atoms, necessary to the formation, is brought about by chemical affinity. Although we cannot reproduce these conditions outside of the body, we can in so far imitate them that the same kind of combination will take place. We have at our command at present many means for the building up of the most complicated organic bodies from the simplest. Some of these are easily understood, and were discovered as the result of strict logical deduction; others are still inexplicable, and were discovered by accident. We can pass readily from one hydrocarbon to another, adding carbon-atoms to an extent which, theoretically at least, is unlimited; from one acid to another of higher order; from alcohol to alcohol; from alcohol to acid; from acid to hydrocarbon; from hydrocarbon to acid, through all the normal series of organic compounds. So great is our power in this direction, that it is possible to produce any member of any regular series of organic compounds from marsh-gas as a starting-point, or from any other member whatsoever. But marsh-gas can be indirectly produced from its elements, carbon and hydrogen; hence, we have the possibility given of preparing artificially by far the greater number of organic compounds. This number includes many of those substances which are formed in the animal or vegetable organism.

The formation of urea and formic acid has been alluded to. With-

out reference to the historical order, a few of the achievements of chemists, which have from time to time astonished and delighted the world, may here be briefly noted. Among vegetable products are oxalic acid, which was formed directly from carbonic acid, a combination of two carbon-atoms being necessary in the process; valeric acid, containing five carbon-atoms; malic acid, with four carbon-atoms, one of the most widely-distributed acids of the vegetable kingdom, being contained in a large number of unripe fruits; cinnamic acid, containing nine atoms of carbon; tartaric acid, the acid of grape-juice. Wintergreen oil, obtained from *Gaultheria procumbens*, has been found to consist mainly of an organic ether, which can be, and has been, prepared artificially. The oil of garlic (*Allium sativum*) contains carbon, hydrogen, and sulphur. It can be prepared with all its properties without the plant. The oil of mustard, with its peculiar arrangement of carbon, hydrogen, nitrogen, and sulphur, is now manufactured on the large scale by a patented process, the mustard-plant being outrivaled by the chemist. The deadly poison conine, and the beautiful colors alizarine and indigo, finally, belong in the same list. In regard to alizarine or Turkey-red, it may be remarked that the discovery of the methods for its artificial preparation has led to the establishment of an important branch of industry of far-reaching influence. It is doubtful, however, whether as much will ever be said concerning the preparation of indigo. Among animal products that have yielded up the secrets of their internal structure to the chemist are the simple fats and the lactic acids. In a great many portions of the animal organism, as the brain, pancreas, liver, lungs, the thyroid and thymoid glands, is found a substance, containing six atoms of carbon, which has been called leucine. This substance is also a frequent product of the decomposition of organic bodies. Leucine is obtained more readily by artificial means than it can be extracted from the tissues in which it exists ready formed. A constant ingredient of the juice of flesh is creatine; and one of the products of decomposition of creatine is sarcosine. Both creatine and sarcosine can be constructed from the elements by purely chemical processes. Taurine, which occurs in the bile, in the contents of the alimentary canal, in the lung-tissue and the kidneys, and contains carbon, hydrogen, nitrogen, oxygen, and sulphur, can be prepared by a very simple process.

These examples suffice to indicate the character of the results already achieved, and furnish justification for the hope now entertained by chemists that in good time it will be possible to produce all chemical substances in the laboratory. No one who has given the subject a sufficient amount of attention to enable him to form an opinion can for a moment feel a doubt on this subject.

The old dogma no longer exists. There are those who sigh at its death; who consider that the sacrilegious step of Science which annihilated it has, in some way, tended to lessen the mystery of life, and

to embolden the votaries of science to look for, work for, further disclosures which may threaten some favorite view—it may be one of more importance than that which we have considered. But others, supporting themselves on the basis that truth can never be dangerous to the right, see no cause for alarm in such advances. They hail them with pleasure, and encourage the spirit which hastens their arrival. In regard to the special question treated in this paper, arguments are hardly necessary to show that the results of investigation, as we have stated them, could not materially modify any time-honored, fundamental views. Is life less of a mystery? Has the question concerning the nature of life been even approached in these researches? We think not. That chemical substances of peculiar structure are found in the living organism is true. That these substances are formed by the action of the force called chemical affinity is just as surely a truth. Do these two truths mutually detract from the importance of each other? When the active agent in the formation of the so-called organic bodies became known, a thousand questions could be proposed to one that could be proposed previously. The conditions for its working became subjects of inquiry, and an almost endless series of possibilities presented itself. From what substances have the new ones been formed? What chemical processes have brought about the final formation? Years—ages must elapse before our knowledge on these points can begin to be exhaustive. And then what? Is the mystery solved? No.

We are ascending a mountain of great light. Our views are becoming more and more extended as we reach higher and higher positions. Should we ever be enabled to reach the summit, there would be found a pleasant harmony in the broad panorama, and our eyes would rest in delight upon it; but the most extensive view has its horizon, the barrier between the visible and the invisible.

## EARTHQUAKES AND THEIR CAUSES.

By JOHN J. LAKE.

THE origin of earthquakes has been assigned to many causes, as the falling in of caverns, steam, the combustion of gases, volcanic and electric action. Their most prominent and peculiar features are the following:

1. Great subterranean noises and reports resembling thunder. These occur more or less during all earthquakes. Father Kircher describes them as "a horrid sound resembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs of the whips cracking;" Sir Hans Sloane, in Jamaica, as

"a hollow rumbling noise almost like that of thunder." At Colares, near Lisbon, in 1755, during the great earthquake, the sound is said to have been "like that of chariots, which increased till it equaled that of the roar of cannon;" and at Lisbon, "a rattling as of coaches in the street, with a frightful noise underground resembling the rumbling of distant thunder." At Madeira the same earthquake was preceded "by rumbling noises in the air like that of empty carriages, which died away like a peal of distant thunder." On the 16th of September, 1849, there was an earthquake at Burra-Burra, in South Australia, where the noise is said to have resembled the rolling of heavy carriages. The shock was followed by a flash of lightning that illumined the whole atmosphere.

2. Another feature of these phenomena is the upheaval of the ground observed during the prevalence of most earthquakes, which is one cause of the sea retiring, another being the suction of the approaching wave when the centre of the convulsion has been removed from the shore. During the great earthquake at Lisbon the bar at the mouth of the Tagus was laid bare by the upheaval, and the master of a vessel, lying in that river at the time, stated that his large anchor was thrown up from the bottom, and seemed to swim on the surface of the water. Other results of the upward movement during this catastrophe were observed elsewhere. The water in a pond at Dunstal, in Suffolk, was jerked up into the form of a pyramid. At some places the water was tossed out of the wells. At Loch Lomond a large stone was forced out of the water. Rocks were raised into the air from the bottom of the Atlantic, and on board a vessel, about forty leagues from the island of St. Vincent in the West Indies, the anchors, which were lashed, bounced up, and the sailors thrown a foot and a half perpendicular from the deck, the ship sinking into the water immediately afterward as low as the main-chains. At Riobamba, in South America, on the 5th of January, 1797, the bodies of many of the inhabitants were thrown, by this vertical action, upon the hill of La Cullca, which is several hundred feet high, and on the opposite side of the river. During some of these convulsions in Italy, paving-stones have been tossed into the air and found with their lower sides uppermost; and, at the time of a late convulsion in South America, the rising of the ground caused the sea to retire, which returned like a wall in appearance, carrying before it inland vessels that had only a few minutes before been left dry, towns and people being overwhelmed by the resistless recoil.

3. Another peculiarity to be noticed in these convulsions is the frequent horizontal and circular motion of the soil. These effects are often very curious, and, in countries much subject to such catastrophes in their severest forms, have often given rise to lawsuits. Walls that had served to divide fields have been completely changed in direction, but without having been shattered or overthrown. Straight and par

allel rows of trees have been inflected, and fields and portions of fields have changed places. Houses have also exchanged situations with each other.

4. It has been observed that clouds have become fixed or suspended over particular spots affected, or about to be affected, by earthquake, as in London, in 1749, in Calabria, in 1783; and it is more than probable that the fog that enveloped Euphemia, in Sicily, in 1638, Millitello in 1693, and other places when they were destroyed, arose from the operation of one cause.

5. Explosions of great violence frequently attend these convulsions, often with disastrous results. When Millitello was destroyed, there was a great explosion heard in the fog that enveloped it; traces were noticed afterward as of the presence of fire on the rocks in the neighborhood, and the vines in the country surrounding it appeared as though they had been seared by fire. A similar explosion was heard in 1783 at Castel Nuovo, in Calabria, when that place was overwhelmed.

6. A further peculiarity is the exemption of certain spots, although the shocks were felt in all the surrounding neighborhood. Thus, at Manchester, in 1777, St. Paul's Church and the Dissenting Chapel escaped. Both of these were low buildings without steeples, and the church situated over a common sewer; but other more lofty buildings, especially those with metal pipes attached, felt the shocks severely. At Blockley the shocks were experienced strongly at the church, but very slightly at the chapel about 300 yards distant, and the latter was constructed without water-pipes.

7. Earthquakes are very frequently attended by thunder and lightning. At Munster, in 1612, thunder and lightning were heavy during an earthquake; and in Sicily, in 1693, it caused very great mischief. This conjunction of lightning with earthquake was noticed by Luke Howard, and constitutes what he designates "spurious earthquake." One of the cases he mentions occured in Radnorshire: "At Knill Court the oscillation of the house was plainly perceptible, and felt by all the family, and that, too, in several apartments, and was accompanied by a peculiar rumbling noise. At Harpton, a severe storm of thunder and lightning was experienced the same night and at the same time."

8. Peculiar rushing noises have also at times been perceived, as in Staffordshire in 1692, and London in 1749.

9. These convulsions are attended by the disturbance of the magnetic needle, and compasses on board ship are frequently for a time useless. On the 19th of January, 1845, on the Thames steamer, during an earthquake in the West Indies, they revolved on their pivots with great rapidity; and on the 29th of October, 1867, during a hurricane, there were shocks of earthquake at St. Thomas's, and the electrical disturbance was so great as temporarily to render the compasses unavailable.

Such being some of the more prominent peculiarities attending earthquakes, let us now apply them to the theories above referred to, and endeavor to ascertain the causes of these disturbances or the agencies employed in producing them.

They do not support the theory of the falling in of caverns being the cause of these phenomena; for they are invariably attended by an upheaval of the ground, and often with a horizontal or a circular motion. This theory, therefore, cannot be maintained, and more especially as it does not explain the electric and magnetic accompaniments.

The hypothesis that they are caused by steam or the explosion of confined gases has scarcely a better foundation. These agents might produce vertical motion and subterranean noises, but it is difficult to conceive how they could bring about circular motion at the surface; and it is quite impossible that the explosion of gases or the escape of steam could, immediately preceding a shock, attract the clouds floating in the atmosphere, so that they should remain fixed over particular spots. Other characteristics also cannot be explained on this theory, as the lightning and disturbance of the compass.

The volcanic and igneous theory is not so easily to be disposed of; for it appears very clear that volcanic eruptions do produce earthquake. A remarkable instance is that of Santorini in 1650. Earthquake is also very common where volcanic action is extensively developed, as in South America and the neighborhood of Etna and Vesuvius.

Volcanoes produce these disturbances in two ways: 1. By their own direct motion; 2. By disturbing the electric equilibrium in their neighborhood. This electric disturbance was noticed by Pliny, who records that an officer, one of the Decuriones Municipales of Pompeii, was struck by lightning in 79, although the sky was perfectly unclouded; and these indications have been put to practical use. The presence of lightning is also a prominent feature during volcanic eruptions. When Kattleguia, in Iceland, now extinct, was last in a state of eruption, lightning proceeded from it and killed a farmer and his servant, together with some horses and cows. We cannot, therefore, exclude the consideration of volcanoes as producers of earthquake, sometimes by direct action, at others through the medium of electric disturbance.

But by far the most prominent agent seems to be electricity, and the Italians, who suffer so much from these calamities, consider it to be the only cause. The evidences of the activity of the electric fluid in this respect are so palpable that they cannot be controverted. As some may be skeptical on this point, it will not be amiss to examine a few cases in which the operation of this agent is quite apparent.

When considering this part of the subject, we must not omit to notice the frequency with which the greatest weight of these calami-

ties falls upon towns and the neighborhoods of mountains. This is to be accounted for on the electric theory, from these places offering points for the escape of the fluid which naturally flies there to seek a thoroughfare, so to speak. From this cause we have St. Elmo's fire on the masts and yards of ships at sea, and De Saussure's experiences of the escape of the fluid from an Alpine peak. Hence we may infer that towns and mountains create centres of force in these convulsions.

At Münster, in Germany, an earthquake began on December 8, 1612, and lasted for several days. During the shocks, Billenelt Castle, near Münster, built on a rock, "sunk more than the depth of two men's height," a breach being made in the rock itself. The destruction by earthquake and lightning seems to have been great. "If any," says a chronicler of the catastrophe, "have so much heart left as to lift up his hands to heaven, he is presently struck down by thunder and lightning;" "fiery clouds and a direful comet" alarmed the superstitious. The state of the atmosphere must have been very peculiar, even allowing for exaggeration, since the writer referred to states that the appearance of the stars was "changed into prodigious, dreadful, fiery meteors." During this calamity, earthquake, thunder, and lightning, occurred twice every day, but not at the same time.

The earthquake of 1638 disturbed both Etna and Stromboli, causing them to send forth flame and smoke, as though the sources of the convulsion descended deeper than their roots. Father Kircher describes the disappearance of the city of Euphemia, which he was endeavoring to reach at this time, and was in sight of. After a violent shock, on rising from the ground and looking toward the city, he saw only a frightful dark cloud, which surprised him and his companions, as the sky was otherwise very serene. Waiting until the cloud had passed away, they found Euphemia had totally disappeared, and its place a putrid lake.

The earthquakes of 1692, in Jamaica, and 1693, in Sicily, present very strong evidences of general electric disturbance in the globe at those times. One evening in February, 1692, at Alari, in Sicily, the village seemed to the country-people to be in flames. The fire, as they imagined, began by little and increased for about a quarter of an hour, when all the houses in the place appeared to be enveloped in one flame which lasted about six minutes and then began to decay, as from want of more fuel. Many who ran to render assistance observed this increase as they passed along the road, but on entering the village found all to be a delusion. Such appearances of fire and light occur in other localities subject to earthquake, e. g., at Cowrie, Perthshire, one morning before daybreak, in 1842, the light is stated to have been so brilliant that birds were distinguished on the trees. Again, in Sicily, about the 15th of May, following the incident at Alari, two hours before sunset, the atmosphere being very clear, the heavens appeared on a sudden all on fire, without any flashes of lightning or the

least noise of thunder. This lasted, at Syracuse, about a quarter of an hour, when there appeared in the air over the city two bows, the colors extremely bright, after the usual manner, and a third with the extremities inverted, and, as not a single cloud was visible in any part of the sky, the abnormal state of the atmosphere is clear. It was also during this summer that the unusually severe thunder-storm occurred at Geneva that so materially affected the future career of the celebrated Robert Boyle. The earthquakes at Jamaica began on the 17th of June, and their greatest violence seems to have been spent in the mountains. Terrific noises were heard among them at Port Royal during the last shock, and they were so torn and rent as to present a very shattered appearance and quite new forms. In this month Etna emitted extraordinarily loud noises for three days together. A singular circumstance, during this catastrophe at Jamaica, was the derangement of the wind. The land-breeze often failed, and the sea-breeze blew all night, whereas the land-breeze should blow all night and the sea-breeze all day. There was an earthquake on September 8, 1692, in Europe, but I have not yet been able to find out the locality.

Space will not admit of more than noticing some special phenomena of the Sicilian earthquakes, 1693. On the 10th of January the castle of Augusta was blown up by the lightning firing the powder-magazine. At Minco, on the 11th, the shock was attended by "a mighty storm of lightning, thunder, and hail, that lasted six hours." The archbishop's palace at Monreal was set on fire by the lightning. Etna emitted great noises, flames, and ashes, during the shocks that overthrew Catania, but there does not appear to have been eruption. Furla, situated among limestone-quarries, disappeared, and at several parts of the hill the rocks, which were previously almost as white as Geneva marble, had changed, and in the clefts made by the earthquake had become of a burnt color, as if fire and powder had been employed to rend them asunder. Millitello seems to have been destroyed before the 11th of January, for the country-people, who dwelt on the neighboring ridge of mountains, affirmed that it was not to be seen on the morning of that day, to which time, from twelve o'clock on the 8th, it had been concealed in a thick fog. During the interval the mountain that lay on the north side of the town had been split asunder—one portion overwhelming Millitello, so that not an inhabitant escaped. Francofonte, built chiefly of wood, escaped with little damage from the shocks, but was fired by lightning; the spire of the church—wood covered with lead—burnt down, and the nunnery of the Carmelites entirely destroyed so suddenly, that five of the nuns were stifled in their beds. The largest part of the inhabitants of Luochela escaped by flying from the town on the sudden disappearance of the castle, situated on a rising ground. Ragusa experienced shocks on the 8th, with violent thunder and lightning. At Specufurno, on the 10th,

"from morning till night, there was never heard so violent a storm of thunder and lightning, as if heaven and earth had been mixing together;" the town-house and several other houses were destroyed by it. The peasants on the neighboring hills observed that this lightning had burnt the vines so that no crop could be expected for the season.

The earthquake of London, 1749, also exhibited strong symptoms of electric action. The year abounded with thunder and lightning, coruscations frequently appeared in the air, and the aurora removed to the south, showing upon two occasions unusual colors. Dr. Stephen Hales heard a rushing in his house which ended in an explosion in the air as from a small cannon, and attributed it to the escape of the fluid by the steeple of the church of St. Martin's-in-the-Fields, adjoining. The Rev. J. H. Murray refers to the electrical disturbances on the east coast of South America, contemporaneous with the great earthquakes on the west coast in 1868, and considers them related. He describes one storm, just at the time of the earthquake, as giving "an idea of what the bombardment of Sevastopol must have been like."

The phenomena of seaquake are of a similar character. We have ourselves seen electric clouds thrown into auroral forms contemporaneously with the disturbance of the sea at another locality.

Examples might be extensively multiplied, but the above would seem sufficient to show that a leading cause of earthquake is electric action, and that volcanoes sometimes produce the same by direct convulsion, and at others by disturbing the electric equilibrium of a locality.—*English Mechanic.*

## ANIMAL LIFE IN MADAGASCAR.

THE large island of Madagascar has of late excited a special interest among the lovers of natural history; the richness of its soil has been acknowledged, and the character of its vegetation and of its animals classified. During the present century, Europeans have chiefly visited the northern part of the island, and expressed in glowing language their admiration of its shores. The bay of Diego-Suarez, which is situated in the most northerly point of the island, is spoken of as one of the wonders of the world, and that of Passandava most enchanting. This, however, is not a fair picture of the whole; like other islands, it presents very striking contrasts. A recent traveler, M. E. Blanchard, who has visited certain parts of the island, chiefly to explore its mineral resources, describes in his book ("L'Île de Madagascar," J. Claye, *imprimeur*) the great chain of mountains and the

desolate solitudes to the west of Imerina, where there are immense tracts that no one has trodden. In one part, Nature displays her boundless riches, where the native can live without working, and civilized man procure the enjoyments of material life; in another, the ungrateful land scarcely yields any food; the rocks are sterile, the soil is bare, and a stream of water to render the existence of man or beast possible, is not to be found.

Climbing with difficulty the high, abrupt downs, the pathway has to be opened through thorny bushes, and plains stretch out at the summit; not a tree or shrub is to be seen; desolate, uninhabitable, and depressing, as the deserts of Egypt and Arabia. After a long march through the sand, a new scene opens; the nopal is now found growing—a sure index to the abode of man. These plants, upon which the cochineal insect chiefly lives, are natives of America, but have long been naturalized in Africa and the south of Europe; the Arabs no doubt introduced them into Madagascar. Wherever a country is unwatered by streams, they are an invaluable resource for the inhabitants. Here, every family possesses its plantations of nopals, and gathers the fruit in a peculiar manner. With the point of their lances, they adroitly detach them, thus avoiding their redoubtable thorns; and roll them in the sand to get rid of the silky covering which incloses these spikes, afterward peeling them with the iron point of the dart. They appease hunger, assuage thirst, and permit the poor people to live in places where, for weeks together, water is not seen.

In these solitudes, where the forests are immense, animal life can multiply without fear of man, and yet the fauna of Madagascar offer some singular features. The traveler can pass along without fear of the lions, leopards, and panthers of Asia and Africa; neither do zebras and quaggas gallop over the plains. In other countries, wherever the climate is hot enough, monkeys enliven the woods; here, not a single species is to be found. The horse and the ass are unknown; and, what is still more extraordinary, ruminants, such as stags and antelopes, are absent. It is true that there are large herds of cattle, which constitute the great riches of the Malagaches, as the natives of Madagascar are called, but they have been imported probably from the southern part of Asia. This species is remarkable from its boss or lump of fat on the back, and is strikingly beautiful when seen in large herds wandering over the plains. The sheep, too, are peculiar, from their enormous tails, which consist of a mass of fat—a common feature in those belonging to the African Continent. Goats are common, as well as wild-pigs, which ravage the plantations; but these are supposed to have all escaped from vessels, and not to be indigenous to the island.

The monkeys of other lands are, however, replaced by the lemurs—graceful little creatures of many different varieties. There is a great resemblance in their attitude and manner of life to the ape, so that

they have been styled monkeys with the fox's muzzle. Their agility is marvelous; they leap through the air to a great distance, settling on a branch, which perhaps bends under their weight, and dart off again in evolutions of astonishing rapidity. A wood frequented by troops commands the astonishment and admiration of the traveler, from the intelligent appearance and incessant gambols of these lively animals. The largest kinds are about three feet in length, while the smallest are not larger than a rat. The true lemur, which is distinguished by a long snout and tail, prefers fruit for food, but does not object to crunch a small bird, a lizard, or insects. These are diurnal in their habits; while the chirogales, possessing short paws and pointed teeth, shun the light, and only appear in twilight and moonlight, when they make great havoc among lizards and small game. These curious mammifers are characteristic of Madagascar; other species do exist elsewhere, but the nocturnal kind are found nowhere but in this and the Comoro Islands.

In the most solitary parts of the southwest region lives that strange creature, the aye-aye, or chiromys. A nocturnal animal, gentle and timid, it is about the size of a cat, with a large head, round full eyes not dissimilar to those of the owl, an enormous tail, and most extraordinary formation of the fore-paws; the middle finger being long and slender. This, which looks like a deformity, is, in truth, a wonderful arrangement of Nature for its special way of life. As it lives on the larvæ hidden in the trunks of trees, the finger can be easily introduced into the fissures from which it tears the coveted prey. Naturalists think it forms a link between the squirrel and the monkey. The Malagaches seem to be impressed with a superstitious dread of the animal, owing to its sleeping all the day in the most secret haunts; nor do they ever molest it, astonished as they seem to be by its peculiar physiognomy and movements.

There is another class of mammifers peculiar to this island, which are called tendraks by the natives, and seem closely allied to our hedgehogs. Like these, they are covered with spines, but the teeth differ, and the tail is wanting; neither do they roll themselves into a ball, but hide the head between their paws when frightened. Seven or eight species have been discovered, with some variety in the spines, some being soft, and not covering the whole of the body. They are all nocturnal in their habits, and very good when cooked. As for the carnivora, they all belong to a very small type. The wild-cat is a pretty creature. Its back is fawn-colored, traversed by four stripes of reddish-brown, and yellowish-white under the body and the paws. The ichneumon, with its long thin body and shaded skin, also gains the admiration of the traveler; it is a fearful enemy to all small or weak animals, but one of the species feeds greedily on honey. Not the least curious is the cryptoproctus, of the size and appearance of a cat, but with feet formed like those of a bear, the entire sole

resting on the ground. No other example of a plantigrade animal is known.

The masked wild-boar, which is still more ugly than its European fellow, is the only mammifer met with both in Madagascar and Africa. It is a hideous creature, with high withers, low back, and little hair. It boasts of an enormous tubercle, supported by a bony prominence in the jaw, which renders the face of the animal extremely disagreeable. A species of gray squirrel, which lives in hollow trees, and bats, complete the list of the mammifers yet known in Madagascar.

It is very different as regards birds; they can cross immense spaces; and so the tern, the petrel, the albatross, and many other well-known birds, abound in this island. It is a charming sight, on a sunny day, to see flights of ducks with brilliant and varied plumage paddling and diving on the rivers or lakes. One large species, with bronze and violet reflections, like metals, its white head and neck spotted with black, is a great favorite with the natives. A beautiful teal-duck, only known here, has an exquisite blending of brown, fawn, and slate-colored plumage, with fair white wings. In the marshes stalks the proud sultana-hen, with its magnificent blue body, a red patch on its head, and coral feet adorned with a tuft of white feathers, by which it is easily distinguished among the reeds. The jacana, a bird of the water-hen family, is also peculiar to this place; mounted on long legs like stilts, and extremely long feet, it runs through the long grass, or upon the floating water-leaves, with wonderful rapidity.

The sacred ibis of the Egyptians is found in large flocks, as well as the green variety of Europe. The crested ibis is peculiar to the country; a beautiful bird, bright-red, with yellow beak and claws; a green head, from which the long plume of white and green feathers lies back. Another bird, classed among the *Gallinaceæ*, is remarkable for the length of its beak; while the pretty blue and green pigeons afford plenty of sport for the lover of the gun. Near the streams, the nelicourvi, a green-plumaged bird, builds its nest among the leaves, composed of bits of straw and reeds artistically woven together. The magnificent cardinal, in its bright scarlet robe of feathers, black-spotted on the back, haunts the open glades of the forest; and on the banks of streams are numbers of linnets, wagtails, and humming-birds, which are almost as small and graceful as the American ones, in addition to possessing all their beauties. The one which is the most common is also the most beautiful, with its bright-green body shaded with violet; the large feathers of the wings, brown-edged, with a violet band on the breast, succeeded by one of brown; and yellow beneath. The family of cuckoos is well represented; the blue variety is a magnificent bird, common in the woods on the shore.

As for the reptile class, it is pleasant for the traveler to walk through the forests knowing that the venomous species are unknown.

Two hundred years ago, the old traveler Flacourt declared that the serpents were all inoffensive; recent experience confirms the fact. The largest is named *Pelophilus Madagascariensis.* There are others, such as the *Langaha nasuta* and *Crista-galli* (zoölogists having retained the name they bear among the natives), which are very singular, from the prolonged form of the snout, arising from the skin being lengthened out. Beautiful lizards, covered with brilliant scales of olive or fawn, spotted with black, white, and yellow, hide themselves under the stones, in the moss, or in old trees. But Madagascar is especially the land of chameleons; in the heart of the forests, they may be seen crouched on the branches, calm and immovable, rolling their large eyes. The crocodile is the only creature to be feared, and accidents from it are very rare, as the inhabitants greatly object to venturing into water.

The insects of Madagascar offer a thousand types for admiration. There are valuable kinds, furnishing wax, honey, and silk; the first two forming one of the natural riches of the island. The bee peculiar to the country has a black body, red underneath; it is very abundant in the woods, and makes its nest in decayed trunks of trees, whence the Malagaches tear the comb.

But there was an epoch when much more remarkable animals lived in Madagascar. In the marshes near the river Manoumbe, at no great depth, a great number of bones of the hippopotamus, of colossal tortoises, and of the limbs and eggs of the *Œpyornis maximus*, have been found. The eggs of this king of birds are six times larger than those of the ostrich; and it was at first hoped that, in the hitherto unknown solitudes of the interior, some living specimens might be found; that hope has, however, vanished, though it is evident they once existed in great numbers in the southwest part of the island. They were of various species, and of different sizes. At the same period, the hippopotamus must have been abundant, as the bones of fifty skeletons were picked up in a few hours. This species, of very inferior dimensions to that frequenting the Nile, is entirely extinct.—*Chambers's Journal.*

## SKETCH OF PROFESSOR STOKES.

THE subject of this notice, GEORGE GABRIEL STOKES, was born August 13, 1819, at Skreen, in the county of Sligo, Ireland, his father being rector of the parish. At an early age he was sent to a school at Dublin, conducted by the Rev. R. H. Wall, D. D. Here he remained for about three years, when he entered a college at Bristol, as a preparation for the university. After two years spent at Bristol, young Stokes, in 1837, entered Pembroke College, University of

Cambridge, and four years later graduated Bachelor of Arts, at the same time winning the highest honors of the university—the Senior Wranglership and the First Smith's Prize. In the same year he was elected to a fellowship in his college. In 1849 he was appointed to the Lucasian chair of Mathematics in the university, and thus became the successor of Newton. Mr. Stokes enjoyed the emoluments of his fellowship until 1857, when he vacated that position by taking a wife. Later, by an amendment of the statutes of Pembroke, he was reinstated in his fellowship. In 1851 he was chosen Fellow of the Royal Society, and in the following year received the Rumford medal "in recognition of his services to the cause of science by the discovery of the change of the refrangibility of light." The "Philosophical Transactions" for 1852 gives an account of this discovery. In 1854 Mr. Stokes was elected one of the secretaries of the Royal Society. He was President of the British Association for the Advancement of Science at the Exeter meeting, 1869. In 1871 the University of Edinburgh conferred upon Prof. Stokes the degree of Doctor of Laws.

It requires merit of no common order to enable a man to attain the high honor of occupying the chair of Newton, at the early age of thirty. Mr. Stokes's election to the Lucasian professorship was a surprise to the undergraduates of Cambridge, who had expected to see the place filled by some man of European fame. But the wisdom of the choice was soon made manifest, and the students of Cambridge recognized in the new professor not only an exceptionally able and learned man, but also one whose whole heart and soul were devoted to the advancement of his pupils. How Prof. Stokes won the confidence and love of the students is told by Prof. P. G. Tait, who at the time was himself an undergraduate at Cambridge. In a memoir recently published in *Nature*, Prof. Tait writes that, a few months after his election to the chair of Mathematics, Prof. Stokes gave public notice that he considered it part of the duties of his office to assist any member of the university in difficulties that he might encounter in his mathematical studies. Here was, thought the students, "a single knight fighting against the whole *mêlée* of the tournament." But they soon discovered their mistake, and felt that the undertaking was the effect of an earnest sense of duty on the conscience of a singularly modest but profoundly learned man.

As a mathematician and physicist, Stokes stands in the foremost rank, whether of his contemporaries or of his predecessors. "Newton's wonderful combination of mathematical power with experimental skill," writes Prof. Tait, "without which the natural philosopher is but a fragment of what he should be, lives again in his successor. Stokes has attacked many questions of the gravest order of difficulty in pure mathematics, and has carried out delicate and complex experimental researches of the highest originality, alike with splendid success. But several of his greatest triumphs have been won in fields

where progress demands that these distinct and rarely associated powers be brought simultaneously into action. For there the mathematician has not merely to save the experimenter from the fruitless labor of pushing his inquiries in directions where he can be sure that (by the processes employed) nothing new is to be learned; he has also to guide him to the exact place at which new knowledge is felt to be both necessary and attainable. It is on this account that few men have ever had so small a percentage of *barren* work, whether mathematical or experimental, as Stokes."

A partial list of Stokes's contributions to science is given in Prof. Tait's memoir. It is there stated that up to 1864 Stokes had published the results of some seventy distinct investigations. Since that year he has published but little, though it is well known that he has *in retentis* several optical and other papers of the very highest order, which he cannot bring himself to publish in an incomplete form. Many of the papers which have been published by Prof. Stokes are of so rigidly mathematical a character that their titles would fail to convey any idea to the non-mathematical mind. To this category belong the papers entitled "Critical Values of the Sums of Periodic Changes" and "Numerical Calculation of Definite Integrals and Infinite Series." The following incomplete list will serve to show the comprehensiveness of Prof. Stokes's researches in applied mathematics:

"On the Friction of Fluids in Motion, and the Equilibrium and Motion of Elastic Solids," 1845; "Effects of the Internal Friction of Fluids on the Motion of Pendulums," 1850.

Of Stokes's papers stating the results of his researches on the "Undulatory Theory of Light," three are cited by Prof. Tait, viz.: "Dynamical Theory of Diffraction," 1849; "On the Colors of Thick Plates," 1851; "On the Formation of the Central Spot of Newton's Rings beyond the Critical Angle," 1848.

The "Report on Double Refraction," in the "British Association Reports for 1862," was drawn up by Prof. Stokes.

"On the Variation of Gravity at the Surface of the Earth," 1849.

"On the Change of the Refrangibility of Light," 1852. This paper contains his famous experimental explanation of fluorescence, which earned for its author his fellowship in the Royal Society.

Among the papers published by Stokes since the year 1864, two are specially worthy of mention, viz.: "On the Long Spectrum of Electric Light," and "On the Absorption Spectrum of Blood."

In conjunction with the late Mr. Vernon Harcourt, Stokes made a highly-valuable experimental inquiry into what is called *Irrationality of Dispersion*, chiefly with a view to the improvement of achromatic telescopes.

"There can be no doubt," writes Prof. Tait, "as was well shown by Sir W. Thomson in his presidential Address to the British Associ-

ation at Edinburgh in 1871, that Stokes (at least as early as 1852) had fully apprehended the physical basis of spectrum analysis, and had pointed out *how* it should be applied to the detection of the constituents of the atmospheres of the suns and stars. Balfour Stewart's experiments and reasoning date from 1858 only, and those of Kirchhoff from 1859."

Prof. Stokes, however, gives due credit to Kirchhoff. Thus, in his Presidential Address to the British Association, in speaking of the applications of the spectroscope, he says:

"But how shall we find in such distant objects as the stars an analogue of the bell which we have assumed in the illustration drawn from sound? What evidence can we ever obtain, even if an examination of their light should present us with rays of definite refrangibility, of the existence in those remote bodies of ponderable matter vibrating in known periods not identical with those corresponding to the refrangibilities of the definite rays which we observe? The answer to this question will involve a reference, which I will endeavor to make as brief as I can, to the splendid researches of Prof. Kirchhoff. The exact coincidence of certain dark lines in the solar spectrum, with bright lines in certain artificial sources of light, had previously been, in one or two instances, observed; but it is to Kirchhoff we owe the inference, from an extension of Prevost's theory of exchanges, that a glowing medium which emits bright light of any particular refrangibility *necessarily* (at that temperature at least) acts as an absorbing medium, extinguishing light of the same refrangibility. In saying this, it is but just to mention that, in relation to radiant heat (whence the transition to light is easy), Kirchhoff was preceded, though unconsciously, by our own countryman, Mr. Balfour Stewart. The inference which Kirchhoff drew from Prevost's theory thus extended, led him to make a careful comparison of the places of the dark lines of the solar spectrum with those of bright lines produced by the incandescent gas or vapor of known elements; and the coincidences were in many cases so remarkable as to establish almost to a certainty the existence of several of the known elements in the solar atmosphere, producing by their absorbing action the dark lines coinciding with the bright lines observed. Among other elements may be mentioned, in particular, hydrogen, the spectrum of which, when traversed by an electric discharge, shows a bright line or band exactly coinciding with the dark line C, and another with the line F.

"Now, Mr. Huggins found that several of the stars show in their spectra dark lines coinciding in position with C and F; and what strengthens the belief that this coincidence, or apparent coincidence, is not merely fortuitous, but is due to a common cause, is, that the two lines are found associated together, both present or both absent. And Kirchhoff's theory suggests that the common cause is the existence of hydrogen in the atmospheres of the sun and certain stars, and its exercise of an absorbing action on the light emitted from beneath."

# CORRESPONDENCE.

### *THE FORM OF LIGHTNING-RODS.*

*To the Editor of the Popular Science Monthly:*

IN a paper in THE POPULAR SCIENCE MONTHLY for August, entitled "The Form of Lightning-Rods," Prof. Phin describes an experiment intended to demonstrate the proposition that electricity of high tension travels through the substance of a conductor independently of its superficies.

Without questioning the general truth of this proposition, I would call attention to one or two flaws in the author's demonstration.

He cites the fact that a moderate charge shatters a strip of gold-leaf, while a stronger one fails to affect a wire having less surface and a greater section. From this he deduces his theorem.

This experiment seems to me unsatisfactory, for the reason that a disruptive force may be supposed to be exerted in both cases, but that the superior strength of the wire enables it to resist what destroys the frail gold-leaf. Of course, the same argument will hold if the effect be ascribed mainly to heat, since but little, comparatively, would suffice to fuse the gold-leaf or even to dissipate it as gas.

Prof. Phin, referring to this experiment, says: "Here we see that, while the electricity was at rest (*static*), the gold-leaf was quite capable of receiving as heavy a charge as the most powerful machine could impart."

It doubtless was "capable of receiving the most powerful charge," but the fact is not proved by the experiment, for, in the position in which the gold-leaf was placed, viz., on the knob of the jar, it was not charged at all!

The charge must have been collected upon the inner coating, through the attraction exercised by the electricity induced upon the exterior. The gold-leaf, in connection with the inside of the jar, was then, properly speaking, no more charged than were objects connected with the outside, e. g., the table, and, to a certain extent, every other object on the surface of the planet. L. H. ANDREWS.

SPRINGFIELD, MASS., *August* 17, 1875.

To the above Prof. Phin replies as follows:

"1. The first objection is to the experiment in which a gold wire is shown to be capable of carrying off a discharge which destroys a strip of gold-leaf presenting a far greater surface. Whether we attribute the destroying power to heat or to mechanical force, it is a fact that the thin gold-leaf is destroyed while the stouter wire remains uninjured, and this is all that is necessary to be known so far as lightning-rods are concerned.

"2. The second objection is, that the gold-leaf in contact with the knob of the jar is not 'charged.' Of course, if the gold-leaf is not charged, the same remark applies to the knob itself; how, then, does it happen that, under such circumstances, the knob will powerfully attract or repel (according to circumstances) a pith-ball brought near it? Probably the most intense charge of static electricity could be imparted directly from the prime conductor. This we have often done, without injuring the most delicate strip of gold-leaf, though the passage of a spark, even without the aid of a Leyden jar, will destroy a strip three-eighths of an inch wide."

# EDITOR'S TABLE.

### *EXPENSIVENESS OF SCIENTIFIC EDUCATION.*

AS we have often said, and as will probably have to be many times repeated and explained before its full meaning is generally appreciated, there are two kinds of education, scientific and non-scientific; or one which brings the mind to bear upon actual things, and another which occupies it with their symbols. One turns the intellect directly upon Nature, and aims to train

it in the acquisition of first-hand knowledge; the other turns it upon books, and exercises the mind upon verbal representations which are accepted in the place of actual things.

This statement, however, though broadly true, requires qualification. Scientific education, of course, neither ignores books nor discredits them for their proper uses; it only subordinates them to its main object—employing them as auxiliaries in the study of Nature. The case is sometimes put extravagantly; extreme statement being thought needful to counteract extreme errors. Prof. Agassiz, for example, as is well known, was often hot in his denunciations of books; but it was their abuse at which his wrath was kindled. He had little patience with the servile habit of learning lessons and quoting books; and he waxed indignant when he saw students stopping with the manual and interposing it between the mind and Nature. His excellent rule was, first learn to know something directly about the subject yourself, and then you will be competent to deal with the representations of others. He saw that it was of primary and vital moment that the student should first of all come at the living phenomena, and learn to read them and think about them independently; and he saw, too, that books are the potent agents by which this desirable object is constantly defeated. Scientific education, therefore, only wars with the perversion of books. Scholastic education, on the other hand, does not propose to go beyond the books. Letters, literature, things written, and the modes of representation, are its ends and its ultimate objects. That the manner is of more account than the matter is the law of gravitation in "culture" or literary education; it governs every thing. The scholar is of course a man, and recognizes as an accident of his being that he is placed in the midst of a system of things which we call Nature. He cannot quite ignore it if he would; he cannot help knowing something of the world he lives in. But he is not concerned about it. He is satisfied with the knowledge of Nature that he picks up inevitably. Natural things, the facts, laws, and order of the world, are not to him objects of mental exercise. He does not recognize them as the means of education; he gives his life to books.

There is, of course, no antagonism between literature and science as mere pursuits; but in the field of education, or as representing methods of cultivating the human mind, they are inveterate rivals. This was less apparent when education was limited to the favored classes, and the scientists and the *littérateurs* could go their respective ways in peace. But in the new dispensation of popular enlightenment, when everybody is to be educated and everybody is to be taxed for the purpose, a conflict arises as to which of the two systems shall have precedence. The people are to be secured a larger measure of mental cultivation. It is their destiny to be occupied with the matter and forces of Nature, and they are creatures of an inexorable system of natural law: shall their education be conformed to these facts, and deal with the direct phenomena of experience, or shall it stop with symbols and be predominantly an affair of books? The issue can neither be forced nor escaped; it belongs to time and the growth of ideas. It is not that Literature is in the saddle and is to be unhorsed by Science; but the undoubted tendencies of the past must work in future with increasing power, and lead, we believe, to the ultimate ascendency of the study of natural science.

But, while recognizing the direction of the great mental movement which marks especially the present age, it will be wise to moderate our expectations and recognize also the formidable character of the difficulties which stand in the way of scientific education. Among these is its great expensiveness. Literary education has here an enormous advantage. Books are cheap. It

is not the label that costs, but the thing labeled. Economy admonishes us to stop with symbols. Phenomena are displayed only as realities; and things real are property and must be paid for. Experimental facilities are expensive, and museum collections represent immense labor. This is a potent reason why there is so much sham in so-called scientific education; or, perhaps, we might more properly say why it falls so far short of what is expected from it. The poor student who cannot get the objects and materials for observation and experiment, is tempted if not compelled to make such shift as he can with books and pictures. This is a difference between the two systems of education which is deep and must continue, and it will operate powerfully to hinder the popular spread of true science. There are, of course, differences in the expensiveness of different branches of scientific study; botany, for example, being cheaper than chemistry. Of the two classes that may be taken generally as most ignorant of the science of their business, cooks and congressmen, it will cost at least ten times more properly to educate the former than the latter.

Yet this difficulty of scientific education is by no means incapable of mitigation, although but comparatively little has thus far been done to overcome it. The training of professional scientific students for the work of research has hitherto engrossed the main attention, and here much has been done to simplify and cheapen operations. Experimental physics is more expensive than chemistry, but efficient efforts are making to reduce the old scales of cost. We notice that, in the scientific school at South Kensington in London, they have adopted the plan of putting the student methodically at work, at the outset, to make his own apparatus. This is an important step, as a short apprenticeship of this kind soon renders him to a very considerable degree independent of instrument-makers, and enables him to go on with his inquiries by utilizing resources that may come to hand in almost any circumstances.

Yet the problem from our point of view is still unresolved. Scientific education, in its popular aspect, does not aim to make investigators or discoverers; it only proposes to acquaint general students with some of the branches of science which may be selected, but to do it by actual familiarity with their subject-matter. What may be now fairly demanded is, that a certain portion of physics, chemistry, botany, or zoölogy, be actually mastered; that is, their phenomena and facts shall be seen, and their principles known by all who take a liberal course of study. This is indispensable to counteract the evils of a purely book education, and to avoid the uncertainty and illusiveness that prevail in the realm of mere words. The importance of this end being admitted, the question remains, how to provide the most economical facilities for this kind of study. It is beyond doubt possible, by the employment of suitable objects that are everywhere available, to give reality and thoroughness to scientific study without great expense; but the method of doing this has yet to be elaborated. Perhaps the only exception to this statement is botany, which can be studied so cheaply that there is no excuse, on the score of cost, for not introducing it forthwith into all common schools. A method has been developed, which is rigidly based upon the principle that the pupil shall study the actual objects at first hand, so that he may "know what he knows" of this interesting subject, and not stop with book representations of it, while the objects of examination are to be had everywhere by merely plucking them. Something like this, as far as it shall prove possible, is yet to be accomplished for the popular study of physics, chemistry, and zoölogy.

### *PROGRESS OF NATURAL HISTORY.*

A COMPREHENSIVE German work on natural history, entitled a "Hand-Book of Zoölogy," by Prof. Carus, assisted by Prof. Gerstäcker, has just been completed. Its publication by Engelmann, of Leipsic, was begun in 1863, and the last volume has been recently issued. The work is reviewed in *Nature* by Prof. E. Ray Lancaster (editor of Haeckel's great work, soon to be issued), and of the general merits of the Hand-book he speaks as follows:

"As the latest complete systematic treatise on the animal kingdom, and one executed with the exercise of most conscientious care, and a very exceptional knowledge of the vast variety of zoölogical publications which now almost daily issue from the press, this work is one which is sure to render eminent service to all zoölogists. We can speak to the usefulness of the earlier volume, from an experience of some years, and there is every reason to believe that the one just completed will be found as efficient."

Having pointed out, with some detail, the scope and characteristics of Prof. Carus's treatise, Dr. Lancaster proceeds to estimate it with more special reference to the later advances of biological theory, and his remarks upon this subject are so opportune and instructive, that we quote them at length. They afford an excellent illustration of the broad applicability and practical bearing of these modern doctrines in relation to life, doctrines which are still characterized by many as "unfruitful speculations."

"Prof. Carus suffers in this book as in his 'History of Zoölogy,' from the unphilosophic conception of the scope and tendencies of that division of biology which its early history has forced upon modern science. In England our newest and most conservative university continues to draw a broad distinction between what is called comparative anatomy and what is called zoölogy. By some accident zoölogy is the term which has become connected with the special work of arranging specimens and naming species which is carried on in great museums, and which has gone on in museums since the days when 'objects of natural history,' and other curiosities, first attracted serious attention in the sixteenth century. Accordingly, zoölogy, in this limited sense, has taken the direction indicated by the requirements of the curators of museums, and is supposed to consist in the study of animals not as they are *in toto*, but as they are for the purposes of the species-maker and collector. In this limited zoölogy, external characters, or the characters of easily-preserved parts which on account of their conspicuousness or durability are valuable for the ready discrimination of the various specific forms, have acquired a first place in consideration to which their real significance as evidence of affinity or separation does not entitle them.

"From time to time the limited zoölogists have adopted or accepted from the comparative anatomists hints or conclusions, and have worked them into their schemes of classification. But it does seem to be time in these days, when pretty nearly all persons are agreed that the most natural classification of the animal kingdom is that which is the nearest expression of the animal pedigree, that systematic works on zoölogy should be emancipated from the hereditary tendencies of the old treatises, and should present to us the classes and orders of the animal kingdom defined not by the enumeration of easily-recognized 'marks,' but by reference to the deeper and more thorough-going characteristics which indicate blood relationships. We have to note in the 'Handbuch' the not unfrequent citation of superficial and insignificant characteristics in the brief diagnoses of taxonomic groups, which seems in so excellent a work to be due to a purposeless survival of the features of a moribund zoölogy that would know nothing of 'insides,' and still less of the doctrine of filiation. For instance, the very first thing which we are told of the vertebrata, in the short diagnosis of the group, is, that they are 'animals with laterally symmetrical, elongated, externally unsegmented bodies;' of the fishes, that they have the 'skin covered with scales or plates, seldom naked;' of the mollusca, that they have a 'laterally symmetrical, compressed body devoid of segmentation, often inclosed in a single (generally spirally-twisted) or double calcareous shell.'

"It would be unjust to suggest that Prof. Carus, who long ago did so much to establish zoölogical classification on an anatomical basis, is not fully alive to the necessity, at the present day, of taking the wide biological view of animal morphology; but cer-

tainly the form in which parts of the book are cast savors of the past epoch. It may be said that the object of the book is to present the 'facts' of zoölogy in a logical order; and that this sufficiently explains the arrangements to which objection might be taken as above, viz., the commencing with the higher instead of the lower groups, the prominent position assigned to external and little-significant characters, the absence of any recognition of the leading doctrine of modern zoölogy, the doctrine of filiation. To this there is nothing to say excepting that of the very *many* logical methods of treatment possible in a hand-book of zoölogy, many are easy to follow out, and that one, which aims at presenting a logical classification of the kind spoken of by Mill, in which objects 'are arranged in such groups, and those groups in such an order as shall best conduce to the ascertainment and remembrance of their laws,' is a very difficult one to follow out. This kind of classification involves nothing less than an attempt (however inadequate) to trace the animal pedigree; for the laws to be ascertained and remembered are the laws of heredity and adaptation. We may regret, then, that so able a zoölogist as Prof. Carus has remained in the old grooves and not ventured on to the inevitable track where Gegenbaur and Haeckel have preceded him."

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## LITERARY NOTICES.

Problems of Life and Mind. By George Henry Lewes. First Series, Vol. II. Boston: J. R. Osgood & Co., pp. 487. Price, $3.

The "problems" discussed by Mr. Lewes in the two volumes which constitute his first series are six in number. Of these, the first, "Limitations of Knowledge," was considered in the preceding volume; the rest are considered in the volume before us. The author's purpose in this series is "to lay down the foundations of a creed, by exhibiting the method which determines all successful inquiry, and by specifying certain general results reached on that method." Thoroughly imbued with the scientific spirit, Mr. Lewes applies to metaphysical discussions the same methods which have in modern times given such brilliant results in the field of natural science. The problems which he discusses are among the most intricate which have worried the mind of man from the dawn of reason. They have been the object of profound study ever since philosophy first had a place in human thought; men have viewed them from every side, and attempted their solution in every conceivable way, but still they remain in all their pristine obscurity. The scientific method of investigation has at last been brought to bear upon these problems, and already we seem to be gaining some headway, under the guidance of Spencer, Bain, Lewes, and their fellows.

The first problem discussed in the volume before us is that of *Certitude.* The author's one test of truth, or of certitude, is the principle of equivalence. When two terms have the same import, i. e., are *equivalent,* they may be predicated of one another; and all errors, both in reasoning and conduct, arise from assuming equivalence in terms where it does not exist. Mathematical truths are exact, necessary, only when the terms in which they are stated are equivalent; mathematical propositions become inexact, or contingent, whenever they are applied to cases involving conditions not included in the terms. The objection might be made that this reduces truth to an identical proposition—"a thing is itself." Yet, in propounding any truth, what more does one intend than to express *what the facts are;* and what is a statement of facts more than the assertion *that they are what they are?* When the two terms of a proposition can be thus shown to be equivalent, the proposition is a truth, and we possess certitude of it. Mr. Lewes shows that this principle of equivalence is the same as the Universal Postulate of Herbert Spencer, of which it is merely the positive statement. Our author's principle is, "Truth is the equivalence of its terms." He states Spencer's principle as follows: "Whenever a subject and predicate are so united that the one term is incapable of appearing to thought without the other, the proposition is necessary; and its negative being unthinkable, the proposition itself must be true." Our author further shows that the three scholastic principles, Identity, Contradiction, and Ratio Sufficiens, are all reducible to the principle of equivalence.

In discussing his second [third] problem, "From the Known to the Unknown," the author analyzes the process of the growth of knowledge; the operation called by logicians Judgment; the process of Ratiocination; Induction, Deduction, and Reduction. He points out the capital error of the subjective or speculative method of advancing from the known to the unknown, as distinguished from the objective or scientific method. The metaphysical thinker imposes his conceptions on phenomena, instead of observing them; he trusts the validity of inferences he has not tested. The scientific thinker, on the contrary, is, or ought to be, on his guard against unverified deduction, and treats it as a tentative process. The process called by the author *Reduction* serves in the hands of the scientific investigator as a check, a test, of his inductions and deductions. Deduction and induction extend knowledge by generalizing acquired results, but reduction criticises these results—retraces their formation step by step, and thus gives to inference a firm basis on sensation. Thus checked and tested at every step, induction and deduction become very serviceable instruments for the discovery of truth. Without such checks and tests their results are simply illusory.

But space fails us to follow the author in his discussion of the remaining three problems, "Matter and Force," "Force and Cause," and "The Absolute in the Correlations of Feeling and Motion." This work of Mr. Lewes is undoubtedly entitled to rank among the highest intellectual efforts of the age.

Printing for the Blind. Report of a Committee of the Social Science Association, at the General Session in Detroit, Michigan, May, 1875. Boston: Alfred Mudge & Son, Printers.

This report would have been more satisfactory had it been prepared by some person familiar with the education of the blind. Some of its statements are so remarkable that we are unwilling to accept them until they have been indorsed by those actually engaged in the work of teaching the blind. In it we are informed that the blind acquire knowledge through reading "painfully;" that "they study geography, algebra, and geometry under heavy disadvantages;" that "composition is for them very difficult because of the time and labor required for the mechanical operation of writing;" that "even the best-equipped asylums (*sic*) are but scantily provided with the most indispensable tools for studying geography and arithmetic." All this is contrary to the generally-received opinions in reference to the education of the blind. We have heard that blind children of tender years learn to read quickly and easily with their fingers; and that they enjoy "Robinson Crusoe" and the "Old Curiosity-Shop," for example, as much as any children. We had supposed, too, that in the study of mathematics the blind possessed some advantages. We had supposed that the art of composition was the hardest to teach to deaf-mutes, and that eminent blind writers as well as blind mathematicians were numerous. There is no other appliance for instructing children, whether sighted or blind, in geography, so complete as dissected relief-maps. We doubt whether in all the schools of New York such maps are to be found except in the two schools for the blind. Was it elsewhere than in a school for the blind that Mr. Ruggles conceived the ideas of his inventions for facilitating the education of the blind? For this report recommends the founding of an institution to devise and construct such appliances entirely separate from any school for the blind. And its authors find indorsement for this scheme in a resolution adopted by the Association of Teachers for the Blind, which, as we read it, simply declares that that Association had found it impossible to work with Mr. Ruggles. This report presents but one side of the case. We shall wait to hear the other side, that of the teachers of the blind, before we decide upon the subject.

Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich. Read at the Annual Visitation of the Royal Observatory, June 5, 1875.

In 1835 the present Astronomer Royal (then Director of the Observatory of the University of Cambridge, England) was called to fill the most important astronomical post in the world, namely, the director-

ship of the Royal Observatory at Greenwich. Since that time he has regularly presented to the Board of Visitors of the Royal Observatory an annual report, and of these the *fortieth* lies before us. In many respects it is like its predecessors; it gives, as they have done, full, even minute accounts of the present condition of the "Buildings and Grounds," of the "Movable Property," of the "Manuscripts," of the "Library," of the "Astronomical Instruments" (in detail), of the "Astronomical Observations" (also in great but necessary detail), of "Spectroscopic and Photographic Observations," of the state of the "Reduction of Astronomical Observations," and of the "Reduction of Photographic and Spectroscopic Observations," of the "Printing" of all the results, of "Magnetic and Meteorological Observations," of the "Chronometers, Time Signals, and Regulation of External Clocks," of the "Personal Establishment," of "Extraneous Work;" and it closes, as its predecessors have done, with a few concise "Remarks" which this year are more interesting and important even than in preceding years.

In other Reports it has been the custom of the Astronomer Royal to draw whatever lessons seemed proper from the work of the past years for the guidance of the observatory in the future, and this has been done in the most concise manner. In this Report the doings of the Observatory in the past and its work for the years to come are spoken of with more freedom and fullness; with so much freedom as to lead some of Mr. Airy's critics in England to speak of it with a kind of fierce joy as his "Valedictory," although nothing is said in it of his retirement. It is impossible to read it without intense interest and without exclaiming, "What a memorable valedictory it would make!"

For forty years the present Astronomer Royal has been the active head of the Greenwich Observatory, and he has been in the most active way concerned in many scientific councils; as he says, "there is not a single assistant or a single instrument in use of those which formed the establishment in 1835," and yet in all these years he has kept steadily one main object in view, and as far as one man can attain it he has attained it. He has gained, with the success of his astronomical plans, the entire and thorough respect and esteem of the scientific world in general, and he may now lay down, if he will, the duties which he has borne so long, sure of the honor and admiration of two generations of his contemporaries.

He points out in this Report, as he has insisted in other Reports, that the Greenwich Observatory was expressly built for promoting methods for determining the longitude at sea, and he shows how the work of Flamsteed, Halley, Bradley, Maskelyne, and Pond (his illustrious predecessors) has been more or less steadily devoted to this object. By none of these, however, has this end been so unremittingly followed as by Airy himself. All the main instruments which the observatory at present possesses, with the exception of the equatorial, may be truly said to have been designed by him with principal reference to the determination of the elements upon which a knowledge of the motion of the moon depends. "Elaborate Star Catalogues" have been formed and immediately published, which are deduced in a uniform manner from the observations, which were made in a uniform way. One steady plan has been followed from 1835 until now, by which results of the very highest value have been attained. The whole astronomical work has been done in one way, and that a wise one; it has been all reduced in one way, probably the best one, and it has been promptly published. This alone would lead to great success. But this is not all: the masses of observations of the moon and major planets which had accumulated from 1750 to 1835 have been carefully taken up, separated, sifted, and discussed upon a predetermined and elaborate plan, and immediately made available to theoretical astronomers. "The lunar reductions are probably the greatest single work ever undertaken in astronomy," so Airy himself says, and he is right beyond a doubt. The needs of astronomy and navigation have been constantly kept in view; the subject of the laws of magnetism in iron ships has been carefully studied, and methods for the correction of ships' compasses have been devised, which are used throughout the world;

regular magnetic observations have been maintained; time-signals are sent all over the kingdom daily, and time-balls are dropped from points such that outgoing ships may see them plainly, and thus regulate their chronometers to Greenwich time on the eve of their departure for sea, and multitudes of chronometers have been tested, purchased, rated, and distributed to seagoing vessels and to scientific expeditions. Meteorological phenomena have been scrupulously registered by approved methods.

Extended experiments on the attraction of mountain-masses were made by Maskelyne, and Airy's Haston-Colliery pendulum experiment is too well known to require more than a mention. Constant assistance has been given to the Government in the training of observers for the transit of Venus, for boundary and other surveys, and for comparison and determination of standards of length, and in many other ways, which the Astronomer Royal does not recount in this Report, but which are well known. His own researches on the theories of the moon and planets, and on scores of allied topics, have made the observatory known throughout the world.

True to the traditions which have brought Greenwich its great success, the Astronomer Royal reiterates in this Report the importance of holding fast to "the fundamental idea"—that of meridional observations; and he indicates that if the force of the observatory must be reduced, that reduction should take place in the photographic and spectroscopic work. He says truly that "the [Royal] Observatory is not the place for new physical investigations," but that it is "well adapted for following out any which . . . have been reduced to laws susceptible of verification by daily observation." He lays down once more and very plainly the principles which have guided him in his long series of useful and honorable labors, and it is well worth the while of all who are interested in astronomy to read this concise expression of them.

We see a new example of how much useful and valuable work may be done in science by the mere force of *persistent* effort in the right direction, and this is a lesson which America needs to take well to heart. By virtue of attention to it, Greenwich can claim that what Delambre said years ago is now doubly true—that if by some great revolution the sciences had perished, while the collection of Greenwich observations alone, with a few methods of calculation, had survived the general wreck, there would still remain sufficient materials for reconstructing the whole edifice of astronomical science.

A Summer in Norway. With Notes on the Industries, Habits, Customs, and Peculiarities of the People, the History and Institutions of the Country, its Climate, Topography, and Productions. Also an Account of the Red Deer, Reindeer, and Elk. By John Dean Caton, LL. D., ex-Chief-Justice of the Supreme Court of the State of Illinois. Chicago: Jansen, McClurg & Co., 1875. Price, $2.50.

We follow with interest the traveler who describes countries and peoples not familiar to us. For this reason we are pleased with Judge Caton's volume, which presents to us a series of pictures, sometimes vividly drawn, of scenery and life on the coast of Norway. His route was from Aalesund, a seaport town in Southern Norway, to Hammerfest, which is more than four degrees within the Arctic Circle, and is the most northerly town in Europe. He also gives an interesting account of a visit to North Cape, made by some traveling companions.

The journey of Judge Caton and his party was by steamers, and nearly all the way among the rocky islands which line the coast. That which seems to have most impressed the party was the perpetual presence of daylight. Day after day the midnight came, but no darkness. This, which was at first pleasing from its novelty, became excessively wearisome before the journey was ended.

The steamer made frequent stops along the coast, but nowhere came alongside the docks to discharge and receive passengers and freight. All this must be done by small boats. The author thought that the most stupid thing he saw in Norway.

Fishing is the principal business of the coast inhabitants—the principal season for cod being in February and March. The rocks were in many places covered with these fish drying for market, or else piled

in stacks after being dried. The journey was made in midsummer, and the melting snows fed innumerable streams which were tumbling over the rocks. The scenery was everywhere beautiful and grand.

At Hammerfest no ice forms in tide-water during winter, and steamers continue their trips from Christiania to Tromsöe near Hammerfest as in summer. Snow, however, falls on the ground quite to the coast, and in great quantity on the mountains. This modification of ocean and coast climate is due to the Gulf Stream.

The author speaks in high terms of the manners, habits, and morals of the Norwegians, but less favorably of the Lapps as respects their culture and refinement. Their morals, however, are good. Those from the mountain districts are rich in their flocks of reindeer. Of these he saw immense droves, but they did not relish the odor of Americans, and he could best approach them against the wind. A chapter is devoted to this animal, and we are promised a volume by Judge Caton on the American and European deer and their domestication.

The Sanitary Journal. Edited by Edward Playter, M. D. Toronto: Dudley & Burns. Monthly. $2.00 per annum.

This is a new venture in the periodical field, having commenced its career a few months ago. Both in its editorial and its selected matter it gives evidence of being conducted with ability. It is to be hoped that the enterprise will be so sustained by the Canadian public, that the editor may be enabled to make good his promise of enlarging the *Journal* at the beginning of next year.

On the Composition of the Ground Atmosphere, together with some Examinations of the Air in Smoking-Cars. By Prof. Wm. Ripley Nichols, of the Massachusetts Institute of Technology.

Prof. Nichols presents in this paper the results of interesting investigations of the quantity and properties of air contained in the soil under a great variety of circumstances; and especially in respect to changes produced in it by processes of organic decay in the soil at considerable depths. The paper, which is of much value, is embodied in the "Sixth Annual Report of the Massachusetts State Board of Health."

Navigation in Theory and Practice. By Henry Evers, LL. D. 263 pages, 12mo. New York: G. P. Putnam's Sons, 1875. Price $1.50.

This book is one of the volumes of an English advanced science series of popular text-books, republished in this country. The work is intended to give the student a clear insight into the theory and practice of navigation. It has been the aim of the writer to make the subject as easy and practical as possible, by presenting the definitions, illustrations, etc., in every variety of aspect. The book comprises thirteen chapters, treating successively and in detail the following subjects: "Definitions and Preliminary Illustrations," "The Compass and its Declination," "The Log, Log-line, and Log-glass," "Plane Sailing," "Traverse Sailing," "Current Sailing," "The Day's Work," "Parallel Sailing," "Middle Latitude Sailing," "Mercator's Sailing," "Great Circle Sailing," "Sailing to Windward or plying to Windward," "Oblique and Current Sailings," and to each chapter are appended numerous examples, illustrations, and exercises.

Contributions to the Theory of Solubility. By Isidor Walz, Ph. D. Philadelphia: Collins, 1875.

This paper is a reprint from the *American Chemist* for February, 1875, in which the author attempts to trace some relations between the solubility of substances, their specific volume, and chemical constitution.

Solution he defines to be the penetration of the molecules of one or more substances into the intra-molecular spaces of another substance. Under this definition are given five distinct classes of solubility, thus: of solids in liquids, of liquids in liquids, of gases in liquids, of solids in solids, including alloys, and of gases in solids, as diffusion of gases through metals. The subject is carefully treated, and is presented in a perspicuous and agreeable manner.

Harvard University. Bulletin of the Bussey Institution, Jamaica Plain, Boston. Part IV. Cambridge: Press of John Wilson & Son, 1875.

Of the six articles which compose the present number, four are especially important as giving the results of original re-

search. Three of these are by F. H. Storer, Professor of Agricultural Chemistry, and are of direct and practical value. One is a "Record of Trials of Various Fertilizers upon the Plain-field of Bussey Institution," another is a "Report on some Analyses of Salt-Marsh Hay and Bog-Hay," and the third one is on the "Fodder Value of Apples." In this last one Prof. Storer says that, while apples contain a very small percentage of nitrogenous matter, they are not to be overlooked as a food for cattle and swine, and should be used with peas, beans, oil-cake, or other highly-nitrogenized food.

An able article is contributed by Prof. Farlow on "Potato Rot," which is illustrated, and one by Prof. Slade on "The Importance of the Study of Applied Zoölogy to the Practical Agriculturist."

Second Geological Survey of Pennsylvania, 1874. Preliminary Report on the Mineralogy of Pennsylvania. By F. A. Genth. With an Appendix on the Hydrocarbon Compounds, by Samuel P. Sadtler. Harrisburg: Published by the Board of Commissioners for the Second Geological Survey, 1875.

This report by Prof. Genth, to be followed by a thorough work on the mineralogy of the State, is an excellent handbook of the minerals of Pennsylvania, and of their localities. Most of the minerals of the State are fully and clearly described, and their analyses, many of which are new, are given. The system of classification adopted is that of Prof. Dana, and the report, although submitted as a preliminary one, is indispensable to every student of the mineralogy of Pennsylvania. The report contains a topographical map of the State, and its general thoroughness is shown in its elaborate index.

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### PUBLICATIONS RECEIVED.

The Better Way: an Appeal to *Men*. By A. E. Newton. New York: Wood & Holbrook. Pp. 48.

Primer of Political Economy. By A. B. Mason and J. J. Lalor. Chicago: Jansen, McClurg & Co. Pp. 67. Price, 75 cents.

Views and Interviews on Journalism. By Charles F. Wingate. New York: F. B. Patterson. Pp. 372.

Geological Survey of Indiana, 1874. By E. T. Cox. Pp. 287. Four Maps.

German Classics. Die Piccolomini; edited by J. M. Hart. New York: Putnams. Pp. 250. Price, $1.25.

Contributions to the Laboratory of the Missouri State University. By P. Schweitzer, Ph. D. Pp. 38.

Notes on Certain Explosive Agents. By W. N. Hill, S. B. Boston: John Allen. Pp. 71. Price, $1.00.

Accidents, Emergencies, and Poisons. Pp. 126. *Also*, Care of the Sick. Pp. 72. Published for free distribution by the Mutual Life Insurance Company of New York.

Preventive Medicine. An Address. By Charles C. F. Gay, M. D. Pp. 12.

The Clinical Thermoscope. By E. Seguin, M. D. Pp. 8. New York: Putnams.

Pseudomorphs of Chlorite after Garnet. By R. Pumpelly. With a Plate. Pp. 4.

Affairs at Red Cloud Agency. By Prof. O. C. Marsh. Pp. 38.

Proceedings at the Eighth Annual Meeting of the Free Religious Association. Boston: Cochrane & Sampson. Pp. 79. Price 35 cents.

Bacteria. By L. A. Stimson, M. D. New York: D. Appleton & Co. Pp. 34.

Examination of Gases from the Meteorite of February 12, 1875. By A. W Wright. Pp. 6.

Report on Trichinosis. By G. Sutton, M. D. Pp. 23.

Catalogue of American, British, German, and French Periodicals. New York: E. Steiger, 22 Frankfort Street. Pp. 16.

On a Fœtal Manatee and Cetacean. By Prof. B. G. Wilder. Pp. 11.

The Age of Ice in Britain. By Prof. Geikie. Pp. 32. *Also*, Insects of the Forest. By A. S. Packard, Jr. Pp. 32. Boston: Estes & Lauriat. Price, 25 cents each.

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## MISCELLANY.

**Detroit Meeting of the American Association for the Advancement of Science.**—The American Association for the Advancement of Science met at Detroit, August 11th, and remained in session a week. Less than the

average number of members were present, but in all other respects the meeting was considered to be quite up to the standard of former years. Increased vigilance by the sectional committee, in the examination of papers offered, resulted in a marked improvement in the interest of the proceedings. Probably at no time in the history of the Association were so many papers rejected as at this meeting; not because they were inferior in merit to many presented at former meetings, but because it was felt that from year to year the time of the Association had been too much occupied in hearing papers read which fell short of a reasonable standard of excellence. It will be another move in the right direction, if the Association will peremptorily check useless discussion, which wastes more valuable time than even the reading of inferior papers. When the presidents of the sections shall have the courage to do this, then will the Association do its allotted work more effectually, and its primary object, the "advancement of science," will be more surely attained. It is worthy of note that the chief papers read in the biological section were in favor of the principle of evolution. "Facts for Darwin" were contributed by Profs. Wm. S. Barnard, E. D. Cope, E. S. Morse, Burt G. Wilder, Messrs. A. R. Grote and Henry Gilman, and Hon. L. H. Morgan. Abstracts of these and other valuable papers follow. The suggestion of ex-President Le Conte, that the national Government appoint a scientific commission for the investigation and repression of our more destructive insect pests, is timely and important, and we hope that, in the interest of both agriculture and pure science, the newspapers of the country will unite in urging the matter upon the attention of the authorities. The value of such commissions, when properly constituted, has been abundantly demonstrated in other countries, and, as Prof. Riley pointed out in some remarks following those of Prof. Le Conte, there is no country in the world more in need of the services of such a commission than the United States at the present time.

The officers of the Association elected for the ensuing year are: President, Wm. B. Rogers, Boston; General Secretary, Thos. Mendenhall, Columbus, O.; Vice-President Section A, Chas. A. Young, Hanover, N. H.; Vice-President Section B, Edward S. Morse, Salem, Mass.; Secretary Section A, Arthur W. Wright, New Haven; Secretary Section B, Albert H. Tuttle, Columbus, O.; Permanent Secretary, F. W. Putnam, Salem, Mass.; Treasurer, Thomas T. Boune, Boston.

The twenty-fifth meeting of the Association is appointed in the city of Buffalo, to commence August 23, 1876.

**Evidence of Evolution.**—The scientific world has for some time been in possession of the fossil wealth of Wyoming and Dakota, but the remains of those early mammalian races had not been placed in relations with the genesis of the human species till Prof. Cope's investigations were published to the Association. The paper which details these researches and their results was no doubt the most important document presented to the Association, and hence we give a rather lengthy abstract of it. According to Prof. Cope, to prove the doctrine of evolution, two propositions must be established: 1. That there exists an orderly succession of structure, corresponding with succession in time; and, 2. That the terms of this succession of structure (species, etc.) actually display transition, or connection by intermediate forms. The first is to be demonstrated from paleontology; the proof of the second is restricted to the observation of living varieties and the discovery of connecting forms.

The structure of the feet is taken to be the best criterion of descent or relationship. The author distinguishes several types of structure of the foot in recent land-mammals, as the *plantigrade*, the *carnivorous*, the *horse*, and the *ox* type. The simplest form of feet is seen in the lowest vertebrata, as lizards, salamanders, which have five toes, with numerous separate bones of the palm and sole which they apply to the ground in walking, The plantigrade type approaches this. In the hind-foot a succession of forms leads from this generalized, many-toed, plantigrade type, to the extreme specializations of the horse and the ox. In any figure of the bones of the human foot, the reader will see two rows called *tarsal* bones, the second row

being followed by a row of long bones, called *metatarsal*, attached to which are the toe-bones. Observe, further, the form and position of the heel-bone and the astragalus, the ankle-joint. Above the foot, and articulating with the astragalus, are two bones, one small (fibula), the other large (tibia). In many reptiles the ends of these bones are nearly equal. Now, in Bathmodon, a mammal from the lowest Eocene Tertiary of New Mexico and Wyoming, the tibia and fibula articulate with the astragalus and heel-bone. As in man, the fibula is the smaller, and the heel-bone is short; the animal walked on the entire sole. From Bathmodon to Horse, on the one side, and Ox on the other, there is a complete succession of intermediate forms, corresponding to succession in time. Thus in Bathmodon the astragalus is nearly flat, while in the ox its upper surface presents a grooved face of a pulley, its under surface an angulated pulley-face, and a small convexity is presented to the hollow of the heel-bone behind. The progression toward this form from Bathmodon embraces these terms: Bathmodon (a gap filled by partially-known genera), Hippopotamus, Peccary, or Oreodon, Deer, Ox. The succession of feet to the one-toed extreme, Bathmodon, Titanotherium (in the Miocene), Tapir, Horse. In the heel-bone there is a succession from the short and flat form of Bathmodon to the long and slender one of the horse and ruminants, and this increase of length is associated with elongation of the bones of the toes, and the passage from the plantigrade to the digitigrade type. Another succession is seen in the diminished number of toes. The series commences in the primitive Eocene types with five digits; in the various series leading to the horse, the ox, the hyena, the cat, the reduction proceeds by the loss of a toe from one side or the other, until, in the ruminants, but two are left, and in the horse but one. In like manner the two bones of the leg, which articulate with the foot and hand, exhibit a succession of changes.

The relation of man to this history is significant. His limbs are those of the primitive type, so common in the Eocene. He is plantigrade, has five toes, separate carpals and tarsals, short heel, flat astragalus, and neither hoofs nor claws, but something intermediate between the two. The bones of the forearm and leg are not so unequal as in the higher types, and the ankle-joint is not so perfect.

A like succession is shown to exist in the forms of the teeth; but we have not the space for even the briefest synopsis of the author's remarks on this point. Thus in limbs and in teeth man retains the characters of the primitive type. From the generalized mammalian fauna of the Eocene the carnivora developed a highly-organized apparatus for the destruction of life. The cloven-footed and odd-toed hoofed orders, are the result of constantly-increasing growth of the appliances for rapid motion over the ground. The ancestors of the carnivora were developing the arts and cruelty of the chase; those of the hoofed orders were developing speed; those of the quadrumana neither speed nor weapons of defense, and nothing was left to them but arboreal life. They took to the trees, and developed the prehensile powers of the feet. In limb and tooth, and digestive system, they remain nearly in the generalized condition from which the other orders have risen. Man's prominence consists solely in the complexity and size of his brain. While the order to which he belongs has made but little progress since the Eocene, in perfecting the organization of the skeleton, it has accomplished the greatest work of all time—the evolution of the human brain and its functions. "The race has not been to the swift, nor the battle to the strong."

**Muscular Structure of the Hands and Feet.**—While Prof. Cope has been working on the osteology of the hand and foot, Dr. William S. Barnard has been studying their myology, or muscular structure. On the history of the muscles the fossil world can throw no light, but Dr. Barnard's investigations of living types seem to demonstrate that muscles have had a history no less significant than the bones. Prof. Cope has shown that, osteologically, the human foot is of ancient pattern. What is it myologically? Let the reader attentively study his own foot; let him experiment on the toes. Try to flex them, and they move, but rather

clumsily. Try to flex a single toe, keeping the rest straight, and the thing will be found to be impossible; they all move together. The big toe may have a little independence, but not much. The Duke of Argyll has lately said, that we can know the animal by looking down from our higher selves upon our lower selves. If the duke would look at an opossum flexing its toes in climbing, and then look down on his own foot, he would have a closer acquaintance with the marsupial. Our toes have the same communal movements as those of the opossum. But our fingers we can flex one at a time or any way we like.

Now, Dr. Barnard's dissections would seem to show that the muscles which move the fingers and toes have been differentiated from one (communis) muscle. He has found many stages of differentiation. The flexor which inserts in the thumb of man inserts in two or three toes in the higher apes. The extensor of the index-finger is the same in the gorilla as in man, but in the lower apes and lemurs it has two parts. In lemurs the third finger gets a tendon from the extensor of the index. In all apes the extensor muscle of the third finger is inconstant. On the theory that the proprius muscles, the flexors and extensors of the fingers and toes, have been developed by specialization out of one communis muscle, these facts and many others of the same kind are luminous; on any other theory they are inexplicable. In the foot, man remains a creature of the past, not modified by that which makes him a man, the brain. The hand has been modified and perfected by its services to the brain.

**The Orang and Man.**—Dr. Barnard's paper on "The Myology of *Simia satyrus*" was based on a dissection he had made of an orang at Cornell University, and dissections of lower apes recently made in Germany. When, in 1818, Traill dissected one of the higher apes, he found a muscle which he homologized with the *gluteus minimus* (one of the abductor muscles of the thigh) in man. Other muscles in the same region he supposed to represent similar muscles in man. But one muscle he found in the ape, which he thought had no representative in man, and this he named the *scansorius*, or "climbing-muscle." Traill was followed by Owen, Wyman, Wilder, and by Bischoff, who, in his controversy with Huxley, argued from this muscle against a simian ancestry for man. Dr. Barnard shows that Traill was mistaken, and that the other great anatomists were misled by the weight of his authority. What Traill took to be the *gluteus minimus* is the *pyriformis*, and what he figured as a new muscle separating the apes from man, the *scansorius*, is the homologue of our *gluteus minimus*. In the orang, Dr. Barnard finds a muscle which has no homologue in man. It is a mere vestige. It occurs in some of the lower apes, as the lemurs, but has no functional value. It is found in the opossum, but no longer as a vestige. Thus when we go back as far as the marsupials, this muscle, which in man is obsolete, almost obsolete in the higher apes, less aborted in the lower apes, is an active organ, performing certain functions. In the *orang* the two external muscles of the calf do not unite to form one tendon, *tendon Achillis*, as in man. Now, this double tendon Achillis sometimes occurs in marsupials. These researches go far to prove that the muscles of man can be traced backward through the apes to the lemurs, and through them to the marsupials.

**The Study of Mathematics.**—Prof. H. A. Newton, vice-president of Section A, at the Detroit meeting, advocated in his address a wider and deeper study of mathematics by American men of science. American contributions to the science of quantity have not been large; take away from their number three or four volumes, a dozen memoirs, and here and there a fruitful idea, and there is very little left that the world will care to remember. True, excellent text-books have been made here; but Prof. Newton is speaking of additions to our knowledge and not of the arrangement of it. The idea seems to be quite general among us that the mathematics is a finished science, and that it has few fertile fields inviting labor, and few regions to be explored. And yet hardly any science can show on the whole a more steady progress for the last fifty years, or a larger and healthier growth, than the science of quantity. The scientific investigator finds himself again and again arrested in his re-

searches, for the want of sufficient knowledge of the mathematics. Hence Prof. Newton's advice to the young student in almost any branch of science is to acquire, first of all, a knowledge of geometry, analysis, and mechanics, so that the main ideas in them shall ever be familiar to him, and their processes readily recalled. Throughout the chemical and physical sciences, the laws are more and more assuming a mathematical form.

The unwisdom of neglecting the mathematics is again seen by considering some of the problems which appear to be in their nature capable of a mathematical solution. To explain by the accepted laws of rational mechanics all the forces and motions of the ultimate particles of matter, of inorganic matter even, may well be beyond the powers of the human mind. But that some of these forces and motions will be explained, even at an early day, seems to be almost certain. So the essential differences in the chemical elements may not be beyond discovery and explanation. Each line in the spectrum has its definite place, and those places are the results of certain laws of structure of the substance that gives the spectrum, and of its consequent action upon the light which comes from or traverses the substance. The time seems near for a Kepler who shall formulate those laws, and for a "Principia" which shall unite them in their most general mathematical expression. In like manner, along the line which in astronomy and physics separates the unknown from the known, there are hundreds of questions whose solution, if attained, must be in part mathematical.

Prof. Newton then speaks of the *rôle* of the laws of quantity in the sciences of political economy, geology, biology, and psychology.

**Coast-Survey Measurements.**—We take from the *Tribune* the following brief abstract of Prof. Hilgard's paper on "Coast-Survey Measurements." The author described the work of measuring a primary base-line near Atlanta, Georgia. The work is liable to error chiefly from changes in the temperature and instability in the apparatus. As every error in the base vitiates all succeeding measures, in which any errors are necessarily multiplied, it will be seen what care was needed to insure accuracy. The results, obtained by methods which Prof. Hilgard described at length, were tested three times by a repetition of the measurement at different seasons of the year. The greatest error thus detected was a deviation from the average of about $\frac{1}{1000000}$ part of the whole. To increase the severity of the tests, one of the measurements was made backward. Another way of stating the possible error is that it would be a third of an inch in six miles. Already this system of measurement, which is purely American, has elicited high praise abroad, and it will probably be adopted by European governments in their surveys. In previous papers before the Association the superiority of the American method for ascertaining longitudes had been expounded, and this system is now substituted for all previous ones in Europe. The apparatus used will form a part of our centennial display.

**Grasshopper Dinners.**—Prof. Charles V. Riley read a paper on "Locusts as Food for Man." The introductory portion of this paper was historical, tracing the use of locusts as human food to the earliest times of which there is record. Among the Nineveh sculptures are representations of men carrying different meats to a place of feasting, and some of the men are carrying sticks on which locusts are tied. In the book of Leviticus the locust is classed with "clean meats," and elsewhere in the Bible this insect is spoken of as food for man. Herodotus mentions a locust-eating tribe in Ethiopia, and Livingstone witnesses to the existence of this habit among modern African tribes. Even in the cities of Morocco, locusts are offered for sale in the markets and eating-houses. Many American tribes use this insect for food. In Southern Russia the locusts are salted and smoked; in Morocco they are boiled and then fried. Prof. Riley has had the locust cooked in a variety of ways, in order to test its flavor. This he pronounces "quite agreeable." Fried or roasted in their own oil, they have, he says, a pleasant, nutty flavor.

**The Gar-Pike.**—Several papers were read by Prof. Wilder, of Cornell University, who has spent the summer in the West. Of

these one was on the gar-pike. The gar-pike is known to science as a very ancient type of ganoid fish—a sort of living fossil. The young gar has two tails, the one serpent-like and the other fish-like. The former is snake-like in motion as well as in form. It is largest and most active in the very young. As the fish grows, it aborts, and at adult age it is obsolete. Prof. Wilder's investigations show that this temporary tail is a vestige, a reminiscence, a survival. The ancestor of the gar was a reptile, and the young fish still carries the ancestral reptilian tail. Another paper by the same author was on—

**The Sirenia.**—The name we have borrowed from Greek mythology, according to which the sirens were young maidens who sat on the shores of a certain island near Italy, and "sang with bewitching sweetness songs that allured the passing sailor to draw near, but only to meet with death." Why the manatee and the dugong should be called sirenia is not apparent on the surface, for they are not graceful, neither are they sweet singers; besides, they bear no enmity to the human race. Externally the sirenia are whale-like, but internally they are pachyderm-like. Prof. Wilder has dissected a fœtal dugong (secured in Australia by Prof. Ward), and from a study of its structure he concludes that the sirenia are not modified whales, but modified pachyderms, and that they are descended from some ancient hippopotamoid quadruped.

**Porcelain-Clay.**—A paper was read by Prof. Cox, Indiana State Geologist, on a white clay resembling kaolin, lately discovered in Lawrence County, Indiana. A full synopsis of this paper was published in the *Tribune*, from which we derive the following particulars: The Lawrence County bed of porcelain-clay occupies the position of the Archimedes limestone belonging to the Chester group. This limestone has been entirely removed where the clay is found, by the action of water charged with hydrated silicate of alumina and carbonate of protoxide of iron. The water which held these substances in solution is supposed to have contained alkaline carbonates, with carbonic acid in excess. It is thus that the water was enabled to dissolve the limestone, and by an interchange of chemical constituents, the hydrated silicate of alumina was precipitated and the lime carried off in solution. The carbonate of protoxide of iron also continued in solution until it met with a sufficient amount of oxygen for its peroxidation and precipitation. The upper portion of the clay, from one to twelve inches in thickness, is of a light cream-color, free from grit and laminated. Then follow from four to five feet of pure white clay, also free from grit. Beneath this is a clay of similar quality, but slightly stained at the joints with oxide of iron. Prof. Cox calls the white clay *Indianaite;* it has a composition of 12 to 14 per cent. water, 42 to 45 per cent. silica, and 36 to 39 alumina. The area of the deposit is known to be at least 42 acres, and there is little doubt that it is much more extended. Indianaite is now used in the porcelain potteries at Cincinnati, and ware made of it is fully equal to the best English ironstone pottery.

**Are Potato-Bugs poisonous?**—A paper by Augustus R. Grote and Adolph Kayser stated the results of an investigation of the supposed poisonous properties of the potato-bug. A quantity of the bugs were submitted to distillation with salt-water, so as to increase the temperature, the product being four ounces of liquid from one quart-measure of the bugs. This liquid had an alkaline reaction, owing to the presence of free ammonia and carbonate of ammonia. It was perfectly clear, and had a very offensive odor. A tincture of the *doryphora* was next prepared, the bugs having been digested for twenty-four hours in alcohol, which was then evaporated at a gentle heat. The tincture had a decided acid reaction, was brown in color, odor not offensive. On introducing into the stomach of a frog about half a cubic centimetre of the liquid and of the tincture separately, no effect was observed. Hypodermic injection of the distilled liquid was in like manner unattended by injurious results, but the tincture proved fatal when administered in this way. The leg, into which the tincture was injected, was quickly paralyzed, and in thirty minutes the heart had ceased to beat. This tincture, though highly concentrated, con-

tained but a minute quantity of animal acids, of composition analogous to those secreted by the flea or the bed-bug. In the insect last named there are special organs for the secretion of these acids, but no such organs have been found in the potato-bug. The conclusion reached by the authors is, that the potato-bug is not poisonous, and that the cases on record of poisoning supposed to be caused by the bug are in fact traceable to Paris-green.

In the discussion which followed the reading of this paper, Prof. Riley said that his own investigations had satisfied him of the poisonous properties of the *doryphora*. "Experiments on frogs," said he, "are not conclusive. Some people are far more sensitive than others to poisonous influences; and much greater differences are to be expected to exist between man and reptiles in this respect." Prof. Cook stated the results of a series of experiments which he too had made on frogs. He starved the frogs before administering to them a decoction of potato-bugs, and the effect on the reptiles was to make them very sick.

**Chemistry.**—A number of chemical papers were contributed by Prof. J. Lawrence Smith. One of these was descriptive of an apparatus for exhibiting the absorption of gases by palladium. The apparatus consists of slips of palladium and platinum; on being introduced into a flame, the palladium-slips coil up like a scroll, while the platinum-slips retain their original form. Another paper was on "Graphite Oxide, as prepared from the Graphites of the Sevier County Meteoric Iron, and DeKalb County Meteoric Iron." Further, he exhibited a pound-weight of cæsium alum. He gave an account of his unsuccessful attempts to obtain cæsium in the pure state. Small particles of the metal were obtained mixed largely with a carbonaceous compound, but they could not be detached from the black mass, as they took fire on being exposed to the atmosphere.

**Meteorology.**—A new meteorological instrument, designed to measure the effects of various climatic conditions on the human body, was described by John W. Osborne, of Washington. The instrument has a motive power, furnished by a clock, which agitates two pounds of water heated to the temperature of the blood. The water is contained in a paper vessel which permits some evaporation. The water for these experiments was heated somewhat above blood-heat, for quickness in registering and reading. The vessel containing the heated water represents the human body, and the effects of heat, cold, wind, and moisture, can be measured just as they affect the human body, and thus the precise extent of these changes can be registered and formulated.

**Velocity of Electricity.**—We take from the *New York Times* the following abstract of Prof. Joseph Lovering's paper on "An Acoustic Method of measuring the Velocity of Electricity." Practically, he said, electricity has no velocity. According to one experiment, when a very long conductor was used, electricity traveled at the rate of 288,000 miles per second. This rapidity is considerably lessened when a shorter conductor is used, and may come down to barely 800 miles per second. For satisfactory experiment, therefore, the longest possible lines should be used. A wire from Cambridge, Massachusetts, to San Francisco, and thence back through Canada to Massachusetts, about 7,200 miles in all, transmitted a message in two-thirds of a second, and some of this time was wasted through thirteen repeaters. Electricity traveled over 4,000 miles of cable in one second, even under some unfavorable conditions. Prof. Lovering's system connects the wire with tuning-forks, the vibrations of which indicate the ten-thousandth part of a second, or even less. The application can be made, however, only by those who are familiar with acoustics.

**Transportation of Fish-Eggs.**—A recent shipment of salmon-eggs from Glasgow to New Zealand was unsuccessful. The cause of this failure is not known, as every precaution was taken by Mr. Frank Buckland, who superintended the shipment, to insure success. The length of time, says *Nature*, during which the eggs were packed on board ship was one hundred and twenty-one days, or only nine days longer than the

period during which it has already been proved by Mr. Buckland and Mr. Youl that the development of salmon may be safely retarded by ice. A large quantity of the ice surrounding the ova remained till the end of the voyage, so that the temperature of the ice-houses must have been kept very low throughout the voyage. The cases in which they were packed are described as "sodden," so that they did not suffer from dryness. Probably want of ventilation caused the failure of the experiment.

**Ancient Glaciers of the Sierra Nevada at Lake Tahoe.**—In the *American Journal of Science* for August is an interesting paper, by Prof. Joseph Le Conte, on the ancient "Glaciers of Lake Valley," in which is situated the well-known and beautiful Lake Tahoe. The great glacier which filled all the lower part of the valley had its source in the snow-fountains among the mountain-peaks at its southern end. The valley is a trough between two ridges of mountains near the top of the Sierras. It is 20 miles wide, 50 miles long from north to south, and is 3,000 to 3,500 feet deep; its lower half is filled with the waters of Lake Tahoe. This lake occupies an area of about 250 square miles, and is 1,640 feet deep.

On either side of the lake are mountains, but those which still show best the glacial sculpturings are on the westerly side. Some of these rise 3,000 feet above the level of the lake, and are between 9,000 and 10,000 feet above the level of the sea. The surface of the lake is at nearly as great an elevation above tide as the summit of Mount Washington. The ice at its greatest development filled the valley—a vast *mer de glace*—to a height of 300 or 400 feet above the present lake-level, and was therefore about 2,000 feet thick. It moved northward, and was discharged upon the plains; some of it evidently moved down the cañon through which the Truckee River now flows.

This glacier was fed by tributaries from the mountains, and these continued to flow after the great *mer de glace* had ceased to exist. Enormous mounds of *débris*, glacial *moraines*, occur between the lake-margin and the mountains, cut with wonderful regularity by water; and toward the south-western portion of the lake occur those exquisite lakelets which add to the charm of the region. Of these, Fallen Leaf Lake, Cascade Lake, and Emerald Bay, are of wonderful beauty. The green waters of Emerald Bay contrast with the clear blue waters of Lake Tahoe. Lake Valley, in which Lake Tahoe lies, may not have been wholly scooped out by glacial action. Prof. Le Conte suggests that an area of depression may have been formed in the process of elevation of the mountains, which was enlarged and deepened by erosion.

**American Grape-Vines and the Phylloxera.**—Four years ago Prof. Riley went to France to study, on the spot, the grape-*Phylloxera*. Some of the scientific results of this visit—as the establishment of the identity of the European insect with that found in our own vineyards, and the American origin of the *Phylloxera*—are known to our readers; but the practical results are highly interesting and important. His experience, here, having taught him that some of our indigenous vines offered greater resistance to the insect than the European varieties, and that, with European vines, there was no hope of discovering a remedy which would prove practicable and satisfactory on a large scale, and under all conditions, he advised the French grape-growers, as one of the most promising means of restoring the ravaged vineyards, to import American vines, either for their fruit or as stocks for the French varieties. Results are fast justifying this advice. The insect continues to broaden the area of its devastations; and in many sections of Southern France, where but a few years ago the whole country was one great vineyard, the ground is now either entirely or partly devoted to other crops, to which it is poorly suited, or the vineyards are rapidly perishing. In spite of the large national reward for a remedy—in spite of the well-directed and persistent efforts of the government, and of the Academy of Science, to discover one—nothing but submersion, which is practicable to but a limited extent, proves effectual, and by degrees the fact is being acknowledged that all other remedies are futile. The American vines, however, are fast gaining ground, and the people begin to look to them as a means

of restoring their blighted vineyards. From a few rooted plants selected by Prof. Riley, and sent over four years ago to Gaston Bazille, then President of the Central Agricultural Society of Hérault, the demand increased each year, until in 1874 it reached many millions, and we have the curious spectacle of a large exportation of American vines to a country that has hitherto despised them as unworthy of culture. We see from some of the French papers that Prof. Riley has this summer revisited the south of France, and that he has found the American vines flourishing in the midst of the dying and dead French vines, and in the order of the varieties recommended four years ago. To testify their appreciation of his services, the Central Society of Agriculture of the department of Hérault held an extraordinary session at Montpellier, and gave a grand banquet at Palavas, in his honor.

**Formation of Hail in the Spray of Yosemite Fall.**—The *American Journal of Science* for September contains an interesting article, by Prof. Brewer, on the formation of hail in the spray of the Upper Yosemite Fall, as observed by himself on the 14th of April last. This magnificent fall is 1,550 feet high, and at the time, the stream being swollen by rains and melting snow, leaped clear from the rocks into the air and was soon torn into spray. "It seemed," says the professor, "as mobile as smoke, and assumed new varieties of outlines each instant, so light and airy that it seemed as easily swayed by wind as lace, yet it struck with deafening thunder. The concussion was perceptible through the granite for some distance." The discharge of water was estimated at 250 to 300 cubic feet each second.

The water in winter falls behind a great cone of ice which forms from 100 to 200 feet in thickness, and emerging beneath the ice a grand arch is formed like that in the glacier at Mont Blanc, whence the Arveiron flows. Standing at the foot of this upper fall, a thousand feet above the bottom of the valley, Prof. Brewer and his companions felt, in the violent tempest of spray, ice-pellets or *hail* which stung their hands and faces like shot. They fell in considerable quantity, rapidly melting, for the sun shone full on the fall, and the rocks around reflected the heat. The diameter of some of the pellets was estimated at one-tenth of an inch.

Here we have the spray of the water-fall condensed and frozen into hail. The process by which this may occur is clearly stated by Prof. Brewer.

The water, supplied from melting snow, plunges over the cliff at just about the temperature of freezing. "In the fall it appears to be 'atomized' for 1,200 or 1,400 feet of its descent. A great volume of air is drawn into this falling mass along its whole course, the sheet spreading as it descends. The quantity of air is so great that it pours outward on the bottom of the valley and is very perceptible as a cool current more than a mile distant from the base of the upper fall. The air as sucked into the fall is immediately cooled to 32° by the ice-cold water. As it passes in, it is very dry, and the rapid saturation within the sheet is sufficient to freeze a portion of the drops."

**Distribution of Temperature on the Solar Disk.**—From the researches of Prof. Langley, referred to last month in the abstract of Secchi's observations on sun-spots, it appears that, though the nucleus of a spot is much cooler than the surface surrounding it, there is no great difference of temperature between it and the photosphere near the sun's limb, though the difference in brightness is so considerable. In fact, Mr. Langley has shown that the relatively black nucleus actually radiates more heat than the bright photosphere quite close to the limb. Following up this discovery, he has shown that the absorption of light, both in the case of a spot, and of the parts of the sun's surface near the limb, is not accompanied by a *corresponding* absorption of all the heat-rays (invisible as well as visible), so that, taking Sir W. Herschel's estimate of the brightness of the nucleus as $\frac{7}{1000}$ of that of the photosphere, Mr. Langley finds that we receive from a spot fifty times as much heat as light, and a similar conclusion is arrived at with reference to the surface near the limb. On comparing the equatorial and polar regions, no appreciable difference was observed in the heat received.

How this is accounted for by Secchi was stated in the September number.

Prof. Mayer, of the Stevens Technological Institute, adopts a different method of observation, and his results differ considerably from those both of Langley and of Secchi. He causes the image of the sun to fall on the smoked surface of a thin sheet of paper, while the other side of the paper is coated with a film of Meusel's double iodide of copper and mercury. He begins with an aperture of object-glass, which does not give sufficient heat in any part of the solar image to blacken the iodide, gradually increasing the aperture till he gets a well-defined blackened area. This is the area of maximum temperature. The aperture being further increased, the blackened surface extends, and a new area is formed bounded by a well-defined isothermal line. This process is continued till the isothermals of the entire image are mapped out.

Prof. Mayer finds that—1. There exists in the solar image an area of sensibly uniform temperature and of maximum intensity. 2. That this area is *of variable size.* 3. That it *has a motion* on the solar image. 4. That it is surrounded by well-defined isothermals. 5. That the general motions of translation and of rotation of these isothermals appear to follow the motions of the area of maximum temperature, but that both central area and isothermals have *independent motions of their own.*

**One-sided Development.**—In an article entitled "Lop-sided Generations," published in the *Journal of Anatomy and Physiology*, Dr. Hollis points out the existence of the habit of using the right hand in preference to the left among those peoples whose monuments date from the remotest antiquity. What is the reason of this almost universal fact? The author turns to the anatomical mechanism of the human body for an answer. It is known that the right lung, liver-lobe, and limbs, exceed in size those of the left side, involving, of course, a greater amount of tissue-structure, and a larger supply of nerves and blood-vessels for their nutrition. A person walking in a dense fog figures with his feet the segment of a circle; and, if he is right-handed, he takes a direction to the left, because the right leg naturally takes a longer stride. The left side of the brain is larger than the right; it has been shown that the power of verbal articulation in the right-handed is confined to a certain convolution on the left side; and hence we arrive at the fact that in speaking and thinking we use the left side of our brain, this being the result of dextral education. Amnesia and aphasia in right-handed men indicate disease of the left brain. Hammer-palsy and writer's cramp show the results of excessive working of the left brain. Dr. Hollis insists on the necessity of adopting a system of education which will give an equal prominence to both sides of the brain in all intellectual operations.

**The Tribes of Western Australia.**—Mr. John Forrest, of the British Anthropological Institute, in giving an account of the natives of Western Australia, states that they are divided into two great tribes, Jornderuss and Ballavook, which are again divided into innumerable sub-tribes. These great tribes are exogamous: a Jornderuss may not marry a Jornderuss, but must take a Ballavook. Wife-stealing is a constant source of quarreling among them, and the women are frequently speared or killed. The children belong to the mother's tribe. Tattooing and marking on the shoulder and breast are almost universal among these tribes. The rite of circumcision is practised by all the tribes that Mr. Forrest met with, except those of the southwest corner of Australia. It is a religious ceremony, and the men and women part for a fortnight upon the occasion of it. The natives of the interior are entirely without clothing, and suffer much from the cold. They sleep in the open air, except in wet weather, when they build small huts. Cannibalism is common in the interior.

**Science allaying National Antipathies.**—The *Edinburgh Review* expresses the opinion that the study of two sciences, namely, comparative philology and ancient law, has already done much, and is destined to do still more, to bring about an understanding between the people of Ireland and of England. Comparative philology proves, beyond doubt, the connection of the Saxon and Celtic people; and indicates, in a gen-

eral way, that these two branches of the Aryan stem were united during a great part of their history. It was left, however, to ancient law to solve the problem with more completeness, and to determine more clearly the place of Ireland in the great aggregate of Aryan nations. The preface to the third volume of the recently-published Irish "Brehon Tracts" gives a clear account of the development of the ancient laws of Ireland, of their relation with kindred Aryan usages, and of the social life that is reflected in them. Sir Henry Maine, too, has demonstrated that the native laws of Ireland are a mass of archaic Aryan customs. "He has shown that the old forms of Irish life, which he has reconstructed with marvelous skill, have a most striking and curious analogy to those of older races of Aryan descent, in various stages of growth and progress; and he has thus established the true inference, that the supposed barbarism of the Irish people is simply a conceit of undiscerning ignorance; that we may regard Ireland as a plant, of which the development has been checked and arrested, but that she is of the same stock as ourselves; and that we must seek the causes of her misfortunes in circumstances independent of race."

**A Snake-eating Snake.**—One of the recent accessions to the population of the London Zoölogical Gardens is a specimen of the *Ophiophagus claps*, the snake-eating snake. The new-comer has been described by Frank Buckland, who represents him as a very formidable type of ophidian. In length he measures over seven feet; circumference about equal to the thickness of a man's wrist. His virus is as deadly as that of the cobra, and he is, moreover, a regular athlete among snakes. His head is very lizard-like and harmless-looking—not flat and triangular as is the head of the puff-adder, the rattlesnake, or the viper. He has an intelligent eye. Like the cobra, he has a hood which he can expand when angry, and his body is ornamented with very pretty stripes. His mode of attack is peculiar: he glides after you with the swiftness of a hawk after a bird, and when he gets up to his enemy bites him and retires. He is, therefore, more to be feared than the lion, the elephant, or the boa-constrictor; one slight prick, quick as an arrow, of the poison-fang, and the life of the man ebbs out of a minute hole in the skin that would barely admit a needle's point. On his arrival at the gardens the *Ophiophagus* was treated to a live English snake, which he instantly seized and swallowed head foremost.

Mr. Buckland ascribes to Fayrer the credit of having given "the only correct account of this creature's habits, especially that of his eating other snakes." But herein he is corrected by Surgeon-General Stewart, who states, in *Science Gossip*, that *Ophiophagus claps* was discovered by Dr. Theodore Cantor, of the Bengal Medical Service, who described the animal and its habits more than thirty years ago under the name of *Hamadryas ophiophagus* in the *Journal of the Asiatic Society of Bengal.* Surgeon Stewart gives some of his own recollections of the behavior of this serpent, while he observed it in company with Dr. Cantor. He says that it devours rats, mice, and small birds. Once Cantor offered a bandicoot to a *Hamadryas.* The former showed fight, and the latter seemed to be afraid, so the bandicoot was knocked on the head, and so probably the life of the snake was saved.

**Prevention of the Effects of Bee-Sting.**—From a letter in the *British Bee Journal*, by Mr. G. Walker, it appears that immunity from the pain and other injurious effects of the sting of the bee may be gained by inoculation with the virus of that insect. Mr. Walker allowed a bee to sting him upon the wrist, taking care that he received the largest amount of poison, by preventing the bee from going away at once; then he let the poison-bag work, which it does for some time after being separated from the bee. The first day he was stung twice. The effect was rather severe cutaneous erysipelas, disorder of the motor nerve, with the usual signs of inflammation. A few days having elapsed, and the symptoms having subsided, he caused himself to be stung again three times in quick succession. The attack of erysipelas was on this occasion not nearly so severe, still a stinging sensation ran up to the shoulder, and a lymphatic gland behind the ear increased considerably in size, the poison being taken up by the lymphatic system. A few days subse-

quently he was stung thrice, and the pain was considerably less, though the swelling was still extensive. At the end of the next week he had had eighteen stings, and by the close of the third week thirty-two stings. After the twentieth sting there was very little swelling or pain, only a slight itching sensation, with a small amount of inflammation in the immediate neighborhood of the part stung, which did not spread farther.

**Influence of Cobra-Poison on Ciliary Action.**—In the *Monthly Microscopical Journal* for June is given a record of experiments made by Drs. Brunton and Fayrer upon the influence of cobra-poison on ciliary action. Ciliated epithelium from a frog's mouth was treated with a solution of the poison, and examined under the microscope. The cilia were then in vigorous action. Ten minutes later this action was much diminished, and in twenty minutes it had ceased. Again, ciliated epithelium was placed under the microscope, one part being treated with water and the other with the poisoned solution. Ciliary action was at first vigorous in both, perhaps more so in that subjected to the poisoned solution. Eight minutes later, non-poisoned cilia still active, poisoned cilia very feeble. Ten minutes, non-poisoned cilia still active, poisoned very feeble. Fourteen minutes, non-poisoned cilia still active, poisoned cilia very languid. Twenty minutes, non-poisoned cilia still active, poisoned cilia perfectly inactive. From this it is evident that the poison first stimulates and then destroys the activity of the cilia.

The action of the poison on vegetable protoplasm is very different. This subject was investigated by Mr. Darwin, who tested the action of cobra-poison on *Drosera*. A minute drop of the solution (one-quarter grain to two ounces water) acted powerfully on several glands of the drosera-leaf—more powerfully than fresh poison from an adder's fang. On immersing three leaves in ninety minims of the solution, the tentacles soon became inflated and the glands quite white, as by the action of boiling water. The leaves appeared to be killed, yet after eight hours' immersion they were placed in water, and after about forty-eight hours re-expanded. Having immersed a leaf in the solution for forty-eight hours, Mr. Darwin found that the protoplasm was then incessantly changing form, being unusually active. "Hence," says he, "I cannot doubt that this poison is a stimulant to the protoplasm" of plants.

**Copper-poisoned Pastures.**—It was observed by the late Prof. Buckland, the geologist, that the bones of cattle pastured in the vicinity of copper-works became diseased. This observation has been confirmed by his son, Frank Buckland, who has examined the skull of a cow, which had for three years grazed the copper-smoked grass. He describes the substance of the bone as much thickened and enlarged. Instead of the usual ivory-like smooth appearance of healthy bone, it appears to be eaten into minute pits. The lower jaw presents several hard, osseous excrescences, and the general appearance closely resembles that of bones affected by mercurial poisoning, one of the symptoms of which is a superficial deposit of rough, porous bone. Whether the mineral deposited on the grass in the vicinity of copper-works, and which is eaten by cattle, and subsequently absorbed into their system, be copper or arsenic, or arsenite of copper, Mr. Buckland is unable to determine at present, but he intends to have the substance analyzed by a competent chemist. The symptoms of the poisoning are stated as follows by a correspondent of Mr. Buckland: First, the beast appears dull, and its hair is dry; the eyes water, and the belly becomes tucked up; soon the beast shows signs of being in pain when moved; hard lumps rise on the legs and on the ribs; the bones of the head become enlarged, and the eyes appear sunken; the teeth become black and worn; lameness appears, sometimes in one leg only, at other times in all the limbs; in milch-cows the milk dries up.

**Sensitiveness of Silver-Salts to Light.**—In the *American Journal of Science*, for April, M. Carey Lea has a paper on "The Action of the Less Refrangible Rays of Light on Silver Iodide and Silver Bromide," in which the following propositions are maintained, viz.: 1. That these two salts of silver are sensitive to all the visible rays of the spectrum; 2. That silver iodide is more

sensitive than silver bromide to all the less refrangible rays, and also to white light; 3. That the sensitiveness of the bromide to the green rays is materially increased by the presence of free silver nitrate; 4. That bromide and iodide of silver together are more sensitive to both the green and the red rays (and probably to all the rays) than either the bromide or the iodide separately; 5. That, contrary to Becquerel's theory, there do not exist any rays with a special exciting or a special continuing power, but that all the colored rays are capable both of commencing and continuing the impression on silver iodide and bromide.

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## NOTES.

The Acclimatization Society of Cincinnati has had printed muslin handbills offering a reward of ten dollars for "any information that will convict persons of violating" in the vicinity of that city "the laws framed for the protecting of birds."

The Prussian Government offers a prize of 3,000 marks (about $700) for a method which will give plaster-casts the power of resisting periodically repeated washings, without injuring in the least the delicacy of the form, or the tint of the plaster. Also a prize of 10,000 marks (about $2,500) for a material for making plaster-casts of art-works, possessing the advantages of plaster, but which, without any special preparation, will not deteriorate by periodically-repeated washings. The conditions of competition are stated in full in the *Journal of the Society of Arts*, No. 1,177.

From official returns published in the *Sanitarian*, it appears that in the city of Boston there occurred, in the year 1874, 11,717 births, whereof 6,021 were of males and 5,696 of females. The proportion is as one to 28.27 of population. Of the whole number 54.74 per cent. were of foreign parentage by both parents; 66.35 per cent. had foreign-born fathers; 73 per cent. were of parents one or both of whom were foreign-born. Of Irish parentage there was one birth to 20.05 of the population; of native, one to 73.24.

Modoo Soodun Goopta is the name of the first Hindoo that ever dissected a human cadaver; this he did in 1836. Still not till seventeen years later did scientific medicine begin to find favor among the natives of India. At present students in great numbers attend the medical colleges of Calcutta, Madras, Bombay, Agra, and the schools of Lahore and Nagpoor.

During the whole month of June, according to the Monthly Weather Report, vessels navigating the North Atlantic were in danger from ice-drift and icebergs. The steamship Scandinavian, while off the coast of Newfoundland, on the 29th of June, sighted no less than 100 icebergs, many of them of monstrous size.

Captain Lawson, whose book, "Wanderings in New Guinea," is almost universally considered to be a work of fiction, on June 22d read a paper at the London Anthropological Institute on "The Papuans of New Guinea." Before the paper was read several members urged the chairman to require of the author some evidence of his good faith, but the motion was overruled, and Captain Lawson was allowed to proceed. In the discussion which followed, Dr. Busk and others expressed opinions adverse to the author's credibility, and the usual vote of thanks was not passed.

The *Tribune*, of Salt Lake City, announces the discovery in North Mill Creek Cañon, near the line of the Utah Central Railroad, of a rich mine of mica. The belt is said to be about 1,000 feet wide and 1,000 feet long. Sheets of mica three by four inches can be obtained in abundance, and development of the mines will doubtless open beds from which sheets of any size can be taken.

A traveler in Zanzibar states that in that country ants are a great pest. They move along the roads in masses so dense that beasts of burden refuse to step among them. If a traveler should fail to see them coming in time to make his escape, he soon finds them swarming about his person. Sometimes, too, they ascend the trees and drop on the wayfarer.

The telegraphic cable between Anglesea and Ireland was recently taken up for the purpose of repairing a fault which had occurred not far from the former island. The fault was found to have been caused by a minute crustacean (*Limnoria terebrans*), which had pierced the gutta-percha covering of the cable. The application of creosote seems to be the only preventive of the depredations of this little creature.

A highly-improbable story is published in the English newspapers, of the discovery in Syria of a large number of villages, the names of which are unknown to the geographer, and even to the tax-gatherer. No fewer than seventy-nine of these hapless hamlets, so the story runs, have been unearthed in the single district of Damascus, besides about an equal number in other parts of the province, by Medjeddin Effendi, who has been devoting his time and energies to the exploration of old official regis-

ters. He is still, it is stated, busily employed in prosecuting his researches, and it is strongly suspected that a number of other unknown villages will be dragged to light.

Died, June 14th, Prof. Henry d'Arrest, of the University of Copenhagen, aged fifty-three years. The Royal Astronomical Society of England last February awarded to Prof. d'Arrest a gold medal for his "Catalogue of the Nebulæ." At the time of his death he had just completed and published his spectroscopic survey of the northern heavens.

We published a note in the July Popular Science Monthly, on the authority of the *Sanitarian*, giving the annual death-rates of several American cities, as deduced from the mortality of the month of March last. That of the city of Nashville was represented as the highest of the places mentioned, its death-rate being set down at 37.69 per thousand per annum. This was a grave mistake, which it is both a duty and a pleasure to correct. It appears from official documents sent us by the authorities of that city, and based on carefully-collected data, that the mortality in March gives a death-rate of only 26.27 per thousand, a figure considerably below that of several of the other cities named.

At the meeting of the American Association a report was submitted by Prof. Newton on weights and measures. It is there stated that the leading powers of the world have called for a convention during the present year, to provide for the creation and maintenance, in the city of Paris, of an organization to be known as the International Bureau of Verification. This bureau will be charged with the distribution, to the governments of the powers represented, of accurate standards of measurement. The report also contains resolutions providing for a memorial to Congress requesting an appropriation to provide for the expense of commissioners from the United States. These resolutions were unanimously adopted by the Association.

M. Bérenger-Feraud, surgeon in the French naval service, notes a singular custom which he found existing among the Balantes, a tribe dwelling on the banks of the Casamanca, in intertropical Africa. They make the duration of marriage responsibilities dependent on the conservation of the *pagna*, or festive garment given to the wife by the husband on the occasion of their wedding. The woman who wishes to be divorced from her lord has merely to wear out her *pagna* as fast as possible, and then present it in a tattered condition to her family, whereupon she obtains release from the power of her husband.

The Smithsonian Institution and the Indian Bureau are forming a large collection of crania, ornaments, utensils, weapons, pottery, and the like, illustrative of the ethnology and archæology of North America, which will form a department of the Centennial Exposition at Philadelphia. At the late meeting of the American Association a resolution was adopted inviting the International Congress of Prehistoric Archæologists to hold their meeting of next year in the United States. The delegates to the Congress would find, in the collection mentioned above, an abundance of material which could not fail to throw light upon many of the obscure problems of the early history of mankind.

In examining the surface-mud of a shallow rain-water pool, Prof. Leidy observed the movements of a multitude of microscopic algæ, which he referred to the species *Navicula radiosa*. These diatoms were very active, gliding hither and thither, and knocking the quartz-sand grains about. Comparative measurements showed that the naviculæ could move grains of sand as much as twenty-five times their own superficial area, and probably fifty times their own bulk and weight, or perhaps more.

Prof. Ramsay is of the opinion that in pre-Miocene times the Alps were probably higher than they are now, notwithstanding the fact that their present elevation is due to subsequent upheaval. That the Alps suffered very extensive denudation during the Miocene period he finds amply demonstrated by the enormous thickness of fresh-water and marine deposits of Miocene age, now spread over Switzerland, these deposits having been formed by the degradation of the pre-Miocene Alps. An elevation of upward of 5,000 feet took place after the deposition of these strata, but the Alps continued to suffer denudation during the Pliocene and post-Pliocene ages, although it is difficult to estimate the extent of this loss.

A fungus, belonging to one genus with the *Peronospora infestans* of the potato, is at present ravaging the opium-poppy in India. This fungus (*Peronospora arborescens*) is invariably found in the blighted leaves of the poppy. After the parasite has done its work, the leaves of the plant become infested with several other fungi, chiefly *saprophytes*.

The leaves of *Eucalyptus globulus* contain an ethereal oil, of which even half-dried leaves contain 6 per cent., and, according to Gimbert, this oil is a very powerful antiseptic. It will preserve blood and pus as long as carbolic acid, and far longer than oil of turpentine. It prevents also the appearance of fungi and vibrios.

# INDEX.

END OF VOL. VII.